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INTERNATIONAL ENGINEERING COMPANY, INC.
A MORRISON-KNUDSEN COMPANY

CHEVRON PHOSPHATES PROJECT
ENLARGEMENT OF EXISTING TAILINGS DAM
FINAL DESIGN REPORT

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SECTION 1
INTRODUCTION

1.1 PURPOSE AND SCOPE

This report presents the results of our engineering design studies for expansion of the existing tailings disposal system at Chevron Resources Company's phosphate mine near Vernal, Utah.

Existing Tailings Dam No. 2 will be enlarged to crest El. 5,970 feet by the downstream method of construction. A new dam embankment will be constructed which will extend north from Tailings Dam No. 2 around existing Tailings Dam No. 1. This construction will result in one expanded tailings dam and pond encompassing both existing Tailings Ponds Nos. 1 and 2.

The major design objectives are as follows:

- Increase the tailings storage capacity by enlarging existing Tailings Dam No. 2 and constructing new dam embankment to crest El. 5,970 feet.

- Provide an internal drainage system in the embankment to safely route seepage through the dam and its foundation. Seepage water will be collected downstream of the embankment and pumped back into the tailings pond or otherwise disposed of in an acceptable manner.

- Maximize the use of locally available borrow materials and tailings sands in construction of the dam embankment.

- Provide adequate freeboard during operation of the tailings pond to completely contain the maximum design flood without overtopping the embankment.

- o Ensure stability of the embankment under both static and seismic loading conditions.

- o Facilitate construction of the embankment and internal drainage system with construction equipment currently owned by or available to Chevron Resources Company.

The following scope of work was accomplished during the final design studies:

- o Collection, review, and evaluation of available soils, geologic, hydrologic and engineering data from previous studies and investigations of the project site.

- o Field and laboratory investigations to further define the engineering properties of the foundation soils and borrow materials.

- o Engineering design studies consisting of seepage and slope stability analyses.

- o Hydrology studies to determine the maximum flood runoff and required freeboard.

- o Preparation of final design cross-sections, layout, and details for the dam enlargement and internal drainage system.

- o Design of instrumentation and recommendations on inspection and monitoring programs.

- o Preparation of design drawings and specifications and a final design report.

Detailed design of the seepage cutoff and collection system which will be constructed downstream of the enlarged embankment was not included in this scope of work. A conceptual layout of the system is included in the design drawings for information purposes only. Detailed design studies will be performed by others.

1.2 PROJECT LOCATION

The Chevron phosphate operation is located approximately 11 miles north of Vernal, Utah, and covers an area of about 23 square miles. It incorporates an open-pit phosphate mine, processing facilities, and tailings disposal and water supply impoundments. The project is situated on the south side of the east-west trending Uinta Mountains in the northeast corner of Utah (see Figure 1).

The predominant natural features on or near the property are Red Mountain, at about El. 7,800 feet, and Big Brush Creek Gorge, which passes near the mine. Neighboring manmade features are Steinaker Reservoir to the south, Red Fleet Reservoir to the east, and Utah State Highway 44. Chevron's property is bordered by the Ashley National Forest and by land controlled by the Bureau of Land Management (BLM). The property is located at approximately El. 5,900 feet, and Vernal is at El. 5,300 feet. The tailings ponds are sited in a tributary valley to Brush Creek, as described in Section 3.1.

1.3 PREVIOUS STUDIES

The following geotechnical investigation reports and design reports were reviewed for this work:

1. Dames & Moore, "Report of Materials Feasibility Study, Proposed Earthfill Dams near Vernal, Utah, for Stauffer Chemical Company," October 1971. This report is a study of materials available for the construction of two proposed surface-water control earthfill dikes to be located upstream and downstream of the Tailings Pond No. 2.

2. Dames & Moore, "Report of Stability Study, Existing Tailings Embankment near Vernal, Utah, for Stauffer Chemical Company," June 1972. This report presents the results of a stability study of the existing embankment dam at Tailings Pond No. 1.

3. Dames & Moore, "Report of Engineering-Design Studies, Proposed Tailings Pond No. 2 System Near Vernal, Utah, for Stauffer Chemical Company," December 1972. This report contains engineering studies and recommendations for improvement of the existing main dam at the Tailings Pond No. 2 and construction of a downstream retention dam.

4. Dames & Moore, "Geotechnical Studies and Engineering Design Report for Expansion of Tailings Pond No. 2 System Near Vernal, Utah, for Stauffer Chemical Company," December 1979. This report presents engineering studies for the enlargement of Tailings Pond No. 2 to final crest elevation of 5,900 feet.

5. International Engineering Company, Report "Volume I - Field and Laboratory Investigations, Chevron Phosphate Operations, Vernal, Utah," November 1982. This report presents the results of geotechnical investigations for the design of seepage control facilities downstream of the existing tailings ponds and for the design of a new tailings dam upstream of the existing ponds.

6. International Engineering Company, "Design Concepts for New Tailings Disposal Impoundment, Chevron Phosphate Operations, Vernal, Utah," January 1983. This letter report presents the conceptual design for a new tailings pond upstream of the existing disposal sites.

7. International Engineering Company, "Conceptual Design Studies for Expansion of Tailings Ponds No. 2, Vernal Phosphate Project, Vernal, Utah," December 1984. This report contains

the results of the geotechnical investigations and engineering analyses and design studies for the enlargement of the existing Tailings Pond No. 2.

8. International Engineering Company, "Geotechnical Investigation, Chevron Phosphate Concentrator Facility, Vernal, Utah," February 1985. This report presents the results of the field and laboratory investigations and engineering recommendations for the proposed expansion of the concentrator facility which is located north of and adjacent to the existing tailings ponds.

9. Morrison-Knudsen Engineers (formerly International Engineering Company), "Conceptual Design Studies for Expansion of Existing Tailings Pond, Chevron Phosphate Expansion Project, Vernal Utah," April 1985. This letter report presents the design concept for enlargement of the existing Tailings Ponds No. 1 and 2 by the downstream method of construction using local borrow materials and tailings sands.

10. Morrison-Knudsen Engineers, "Conceptual Design Studies for Seepage Control Below Tailings Dams, Chevron Phosphate Expansion Project, Vernal, Utah," April 1985. This letter report presents the conceptual design for seepage control facilities downstream of the existing tailings ponds.

1.4 EXISTING TAILINGS DISPOSAL FACILITIES

The existing tailings disposal facility consists of a main dam and secondary dam impounding Tailings Pond No. 2, and a main dam impounding Tailings Pond No. 1 as shown in Figure 2.

Tailings Pond No. 1 is no longer in operation; all tailings are currently deposited into pond No. 2. The current elevation of Tailings

Pond No. 2 is approximately 5,866 feet. Tailings sand is deposited from the crest of the main and secondary dams creating a tailings beach of variable width.

The crest of the main embankment for Tailings Pond No. 2 is currently being raised from El. 5,876 feet to El. 5,888 feet, and the maximum embankment height is approximately 136 feet. This embankment was constructed in 1973 to approximate El. 5,864 feet using mine-waste material consisting of gravel, cobbles and boulder-sized rock in a matrix of silty, fine to coarse sand. The upstream and downstream slopes in this material are approximately 1.3 Horizontal to 1.0 Vertical (1.3H:1V). A blanket consisting of compacted silty soil was placed over the upstream slope of the dam extending up to approximate El. 5,800 feet.

A berm consisting of compacted mine-waste material was subsequently constructed on the downstream slope of this main embankment. A graded filter zone separates the berm from both the main embankment and the underlying soil foundation. The crest of the berm is at approximate El. 5,780 feet; the width of the berm is about 60 feet. The downstream slope of the dam below the berm is approximately 1.3H:1V.

The crest of the secondary dam embankment is at approximate El. 5,880 feet and the maximum height of this embankment is about 70 feet. The embankment is constructed with dumped mine waste material as described above for the main dam. The upstream and downstream slopes of the secondary dam are both approximately 1.3H:1V. A berm consisting of compacted mine-waste material was subsequently constructed on the downstream slope of this embankment in the same manner as for the main embankment. The crest of the berm is at approximate El. 5,860 feet. The downstream slope of the dam below the berm is approximately 1.3H:1V.

These two embankments form the retaining structures for Tailings Pond No. 2 which currently covers about 100 acres and impounds about 4,400 acre-feet of tailings. These embankments are currently being raised in three stages to El. 5,900 feet by the upstream method of construction, using compacted sand tailings from the beach. The side slopes of this enlargement are 2H:1V. The downstream slope and crests of the three stages of enlargement are covered with 2 feet of mine-waste material.

Existing Tailings Dam No. 1 is located across the small valley north of Pond No. 2. The crest elevation of Tailings Dam No. 1 varies from 5,910 to 5,930 feet and the maximum height of the embankment is approximately 140 feet. The embankment was built up in several stages. An initial 50-foot high starter dam was constructed of random rockfill materials from the mine. The remainder of the dam was raised in the upstream direction using dumped rockfill from the mine. The downstream slope of the embankment is on the order of 1.3H:1V.

Seepage emerging at the toe of the existing dams is collected in several detention ponds downstream of the dams and pumped back to the tailings ponds. In addition, a slurry wall located across the drainage downstream of the main dam intercepts the seepage flowing through the overburden soil. The impounded seepage is also pumped back to the tailings reservoir.

1.5 PROPOSED CONSTRUCTION

The proposed construction consists of (1) enlargement of the existing main and secondary embankments at Tailings Pond No. 2 from crest El. 5,900 feet to 5,970 feet in successive stages by the downstream construction method, and (2) construction of a new dam embankment encompassing the existing Tailings Dam No. 1. The plan and design cross-sections for the enlargement of the embankments are shown in Figures 2 and 5, respectively.

At a crest elevation of 5,970 feet, the dam will have a crest length of 5,600 feet and a maximum height of 254 feet. The pond will have total tailings storage capacity of 28,100 acre-ft. Of this amount, 4,400 acre-ft have already been used, and 20,500 acre-ft is available for future tailings storage. The remaining 3,200 acre-ft of capacity is needed to provide 10 feet of freeboard. Adequate freeboard to contain the design flood will be provided throughout the life of the pond operation. The reservoir area-capacity curve is shown in Figure 1.

Because of the relatively small drainage area (5 square miles) and the low levels of precipitation in this region, no operational spillway is planned. However, a final overflow spillway will be constructed 3 feet below the ultimate dam crest elevation at one of several potential locations shown in Figure 2.

The total in-place volume of fill material needed to construct the enlargement is estimated to be about 6.6 million cubic yards. The embankment will have an upstream slope of 2H:1V and a downstream slope of 2.5H:1V. The crest width will be 30 feet. The fill material for construction of the dam will come from tailings sands, mine-waste rock, and on-site Moenkopi "red beds" siltstone and shale.

The drain system of the dam consists of inclined chimney, blanket, and collector drains and is shown in section in Figure 5. The purpose of this drainage system is to intercept seepage from the tailings pond and to route seepage through the dam and its foundation. The drain system has been sized to safely pass inflows of water from the tailings beach and foundation. Seepage will be collected and subsequently pumped back into the tailings pond.

Tailings will be transported to the tailings pond from the mill via a slurry pipeline. It is anticipated that during the years of operation, primarily slimes will be deposited into the pond. Tailings sands will be excavated from the beach and used for construction of the tailings dam expansion. Discharge of the sands will be from the crest of the dam to develop a beach on the upstream face. Slimes will be discharged into the pond away from the beach area.

A decant barge and clarified water pool will be maintained at the upstream end of the pond, and the pool will be kept as small as possible. Water will be pumped back to the mill for reuse.

A surface- and ground-water cutoff and collection system will be developed to intercept pond seepage and pump it back to the tailings pond. This system may require two or three cutoffs and collection sumps downstream of the tailings dam because of the variable topography in the project area. The system will be designed to intercept all flows through the dam and foundation as well as any leakage which surfaces downstream from underlying rock formations.

The tailings pipeline, decant barge, and surface and ground-water cutoff and collection system are not included in the scope of work for this design report.

SECTION 2

FIELD AND LABORATORY INVESTIGATIONS

2.1 GENERAL

The project site has been investigated on several occasions in relation to successive expansions of the tailings ponds and mine facilities. The results of the previous field and laboratory programs are discussed in the reports listed in Section 1.3.

The additional investigations performed during the final design phase included the following:

- Supplemental field and laboratory investigations to better define the foundation soils.

- Testing of Moenkopi borrow sources and additional field investigation to locate any gypsum strata which may be contained within the siltstone beds.

The detailed scope of the investigations is discussed below. Borehole and test pit locations for all exploration programs are shown in Figure 3 with reference to the exploration dates.

2.2 FIELD EXPLORATION

The current field exploration was performed during 9 April to 14 April 1985. It included drilling of eight boreholes and sampling of soils and rock. The drilling subcontractor was Erickson-Ford Company, Inc. of Boise, Idaho. The field exploration was performed under the supervision of an MKE geotechnical engineer.

The locations of the boreholes are shown in plan in Figure 3. Boreholes HA-1 through HA-6 were drilled along the foundation of the proposed embankment in the areas not covered in sufficient detail by previous investigations. Boreholes HA-7 and HA-8 were drilled through the Moenkopi red bed siltstones in the proposed borrow area which is located along the southern edge of Tailings Pond No. 2.

The boreholes were drilled to depths ranging from 20.1 to 104.0 feet below the existing grade. A truck-mounted CME 55 rig equipped with a 7-3/4 inch hollow-stem auger was used for drilling through the soil overburden and soft rock. The boreholes were advanced through hard rock by rotary drilling with a NW core barrel.

A total of ten undisturbed soil samples were recovered from the boreholes by hydraulically pushing 2-1/2-inch O.D. Shelby-tube samplers into the soil. A total of 34 disturbed soil samples were obtained by performing Standard Penetration Tests (SPT) (ASTM D1586), which also provided blow counts useful for approximating soil strength. In addition, 35 five-foot long runs of NW rock core were obtained. The soils encountered were examined, classified, and logged by our engineer based upon the Unified Soil Classification System described in Appendix A. The rock samples were also classified and their Rock Quality Designation (RQD) values determined.

The borehole logs are presented in Appendix A. The depths at which SPT sample and undisturbed Shelby-tube samples were obtained are indicated on the logs. The SPT blow counts and RQD values are also shown on the logs. Descriptions of materials in the logs are based on visual examination made in the field. Where laboratory test data are available, the visual classifications were modified to reflect these data.

The water level in the boreholes was measured and is also shown on the logs. Fluctuations in the ground-water level are likely to occur due to changes in tailings disposal operations and variations in rainfall. The ground-water depths shown on the logs pertain only to the times of measurement.

2.3 LABORATORY TESTING

A testing program was performed on selected soil and rock samples extracted from the boreholes to establish the physical and engineering properties of these materials. All tests were performed by Rollins, Brown, and Gunnell, Inc., of Provo, Utah. Laboratory test results are presented in Appendix B.

Sieve analyses (ASTM D421 and D422) were performed for five soil samples and hydrometer tests on two of these samples to determine the particle size characteristics. Consolidation tests (ASTM D2435) were conducted on three undisturbed samples to determine the compressibility of the soils. Atterberg Limit tests (ASTM D4318) were performed on three samples to determine the plasticity characteristics.

A falling-head permeability test was conducted on one undisturbed sample. The field moisture content and dry density of seven undisturbed samples were also determined.

The shear strength of the clayey or silty soils was determined by performing unconfined compressive strength tests (ASTM D2166) on three undisturbed samples and consolidated undrained triaxial compression tests with pore pressure measurements on three undisturbed samples.

The quality of potential rock borrow materials was investigated by performing petrographic analyses of two thin sections, bulk specific gravity and absorption tests (ASTM C97) on two rock core samples, and magnesium sulphate soundness tests (ASTM C88) also on two core samples.

Permeability tests (ASTM D2434) are currently being performed on a potential borrow source for drain materials. The results of these tests will be used to confirm the permeability values assumed for design of the drain system.

SECTION 3

SITE CONDITIONS

3.1 SURFACE CONDITIONS

The tailings disposal area is located in an east-west trending valley south of the mill and concentrator facilities. The drainages, across which the three existing embankments are located, join Big Brush Creek about one-half mile downstream from the embankments and about 2,000 feet upstream of the Utah State Highway 44 bridge, which crosses Brush Creek. The drainage basin above the proposed dam has an area of 5.0 square miles and ranges in altitude from 5,850 to 7,200 feet.

Vegetation in the natural valley slopes consists of junipers, sagebrush, and a sparse growth of grass. Natural slope angles range from moderate to very steep. Rock is at or very near the surface of the hills. The soils at the lower slopes of the hills grade from rocky slope wash to alluvium in the bottoms of the gulches. Small tailings deposits and retention dikes exist at the bottom of the drainage downstream of the main dam of Tailings Pond No. 2.

The only man-made features located in the proposed dam and reservoir areas are mine facilities including access roads, pipelines, pumping stations, and a maintenance building. The latter is located at the north abutment of the proposed dam and will have to be removed prior to the construction of the last stage of the dam.

The tailings beach slopes an average of 10 percent from the crest of the main dam and the secondary dam embankments towards the tailings pond water. The surface of the tailings beach is variable in consistency and is eroded at some locations because of the peripheral tailings discharge.

3.2 SUBSURFACE CONDITIONS

A. Geology

The site is located on the south flank of the Uinta Mountain Arch near the east-central part of the range. Rocks exposed within the phosphate mine area are the Weber Sandstone of Pennsylvanian age, the Park City Formation of Permian age, and the Moenkopi Formation, which is of Triassic age. Quaternary alluvial fill is found on the valley bottom.

The Weber Sandstone is a hard, massive, fine- to medium-grained, light gray, cross-bedded quartzose sandstone that forms the high vertical cliffs along Brush Creek in the mine area. The Park City Formation, which is above the Weber Sandstone, consists of interbedded limestone, dolomite, limy sandstone, shale, and phosphatic shale. The phosphatic member at the bottom of the Park City Formation ranges from 20 to 30 feet in thickness. One of the limestone members forms the dip slope surface in the mine area.

Laying conformably on the Park City Formation is the Moenkopi Formation, which consists of thin-bedded, reddish brown siltstone or fine-grained sandstone with thin partings of weak, red, sandy shale and thin beds of light greenish gray, fine-grained sandstone. There are numerous thin veins of gypsum throughout the formation. Because the Moenkopi Formation is soft, much of it has been eroded off the upper limestone member of the Park City Formation. The Moenkopi is the only formation exposed in the study area. The contact between the Park City and the Moenkopi Formations is just to the north of the proposed embankment encompassing the existing Tailings Pond No. 1. The contact between the lower greenish gray sandstone member of the Moenkopi and the interbedded red siltstone, sandstone, and shale is generally along the drainage in which Tailings Pond No. 2 is located (Figure 3).

The structural trend of these formations is north 80 degrees east with a dip of 10 to 15 degrees southeast. No major faults were noted in the project area. Above the Moenkopi Formation, in the hills south of the project site, are rocks of the Shinarump Conglomerate, the Chinle Formation, and the Navajo Sandstone.

B. Embankment Foundation Conditions

The proposed embankment enlargement will be founded on natural alluvial and residual soils, existing waste rock embankments, and tailings sand embankments now under construction. The detailed foundation conditions for each type of material are described in the following paragraphs. A plan of the geotechnical explorations is shown in Figure 3. Geologic profiles are shown in Figure 4.

1. Natural Soils - The following three types of foundation conditions on natural soils are encountered at the site:

- o Soils in the northernmost portion of the proposed embankment
- o Hill slopes
- o Bottom of main drainages downstream of existing dams.

a. Northernmost Portion of the Proposed Embankment - The northernmost portion of the proposed embankment is oriented in the east-west direction along the northern edge of Tailings Pond No. 1. The ground surface slopes gently toward the east. In some areas a thin layer of tailings (3-inch-thick at boring HA-1) covers the natural soils. The natural soils include loose to very dense, tan to gray brown silts with variable amounts of clay, sand, and gravel, and occasional layers of very dense silty gravel. In borehole HA-2, the silty soil contained some gypsum. The soils are dry near the dam abutment and moist at the lower elevations near the existing Dam No. 1. The depth to bedrock is about 12 to 13 feet. Bedrock consists of gray Moenkopi siltsone. The rock is heavily fractured and weathered with gypsum lenses of up to 1/4 inch in thickness. Rock weathering decreases with depth. At the time of measurement, the ground-water depth was determined to be 28.2 feet at borehole HA-2. Ground-water was not encountered at borehole HA-1.

b. <u>Hill Slopes</u> - The hill slides are covered with a thin mantle of residual soil consisting primarily of loose to dense, dry to moist, silt. The soil color varies with the color of the underlying bedrock, that is, greenish gray to light brown at the northern portion of the site and red to reddish brown to the south. Soil thickness ranges from zero to five feet. The silt contains occasional fine gravel and grades to very weathered and fractured, interbedded siltstone and sandstone bedrock. The rock is gray, red, and reddish brown, soft to medium hard, and contains many lenses and hairline seams of gypsum. Weathering decreases with depth.

c. <u>Drainages</u> - The natural soils filling the bottom of the drainage downstream of Dam No. 1 consist of alluvial gray and gray brown clayey silt with depths to bedrock ranging from 10 to 25 feet. The upper 9 inches of soil contain abundant organic material. The soil is soft near the surface and becomes stiffer with depth. At the time of measurement, the ground-water depth was determined to be 22 feet at borehole HA-3 and 8 feet at borehole MW-3. Approximately 600 feet downstream of the dam, a small dike impounds the seepage water which emerges at the toe of the dam.

The bottom of the drainage across which the secondary dam of Tailings Pond No. 2 is located appears to be covered with a thin layer of alluvial soil. Seismic lines SL-7 and SL-8 indicate overburden depths of zero to eight feet. At monitoring well MW-2, which is located at the east end of the drainage, the soil consists of brown sandy and gravelly silt and silty sandy gravels. The soil is loose at the surface and becomes denser with depth. Sandstone and siltstone bedrock was encountered at a depth of 20 feet. At the time of measurement, the ground-water depth was observed to be 12 feet below the ground surface.

The bottom of the drainage downstream of the main dam is filled with alluvium and rocky slope wash from the soft, red Moenkopi Formation. Typically the soil consists of reddish brown, loose, sandy clayey silt to depths ranging from 9 to 20 feet below the natural surface. At the toe of the dam, this silt stratum is underlain by gray and reddish brown, fine to coarse sand and gravel with occasional cobbles and trace of silt. This material is loose to medium dense and extends to a depth of between 43 and 50 feet below the existing ground surface. The sands and gravels are bedded with lenses of sandy silt and some clay. Bedrock consisting of reddish brown soft siltstone and fine-grained sandstone was encountered below the sand and gravel stratum. The rock is highly fractured and weathered and contains numerous thin white gypsum veins subparallel to the bedding. The rock becomes moderately hard and less weathered with depth.

Approximately 400 feet downstream of the toe of the main dam is a 12- to 15-foot-high seepage retention dike constructed with silty gravel and rockfill. The dike is founded on a 13-foot-thick layer of reddish brown, loose silt. The underlying material consists of brown to reddish brown, medium dense to dense, gravelly sandy silt. Bedrock was found at a depth of 50 feet below the crest of the dike, or 35 feet below the original ground surface.

The ultimate toe of the proposed embankment enlargement will reach approximately 200 feet downstream from the existing seepage retention dike. The log of monitoring well MW-1, located in that area, indicates that the upper 20 feet of the soil consists of alluvial, red, sandy clayey silt. This soil is loose, nonplastic, moist, and contains a little fine gravel. A 23-foot-thick layer of reddish brown, loose, sandy gravel was encountered under the silty soil. This material overlies sandstone and siltstone bedrock. The rock is reddish brown to dark brown, fine grained, soft, and highly weathered and fractured. It contains numerous thin white gypsum veins up to 1/8-inch in thickness.

An old slimes pond is located downstream of the ultimate dam toe line (Figure 3). The slimes consist of light greenish brown, very soft, highly plastic clay. This soil is slightly organic, with traces of lignite and plant fibers. In some areas it is covered with a 2- to 2.5-foot-thick layer of reddish brown, nonplastic to slightly plastic sandy clayey silt with abundant organic material.

The ground-water table in the drainage fill is fed by seepage from the main dam and from the retention pond. As a result, at the bottom of the drainage, the water table is generally only a few feet below the ground surface.

2. Existing Waste Rock Embankments - A portion of the upstream slope of the proposed enlargement will be founded on the downstream slopes of existing waste rock embankments. These embankments were constructed with stripped overburden materials from the mine area. The material forming Dam No. 1 consists of medium dense to dense, gray to light brown, silty fine to coarse sand and gravel with occasional cobbles and boulders.

The soils in the main and secondary dams of Tailings Pond No. 2 are a mixture of light grayish-brown, fine to coarse gravels, cobbles, and boulder-sized rock in a matrix of silty fine to coarse sand. The material ranges from loose to medium-dense and contains large zones where segregation of sizes has occurred. Stabilizing rockfill buttresses were constructed on the downstream slopes of the dams using selected mine waste material, as described in Section 1.4. Filter zones consisting of sand tailings were placed between the embankments and the buttresses. The buttress materials were placed in compacted lifts.

3. Tailings Sand Embankments - As indicated in Section 1.4, Tailings Pond No. 2 is now being raised by means of tailings sand embankments constructed by the upstream method. The upstream toe of the proposed enlargement will be founded on the downstream slope of the compacted sand embankments, which in turn are founded on the sand beach of the tailings reservoir. The soil conditions at the sand beach and compacted sand embankments are discussed below.

Previous investigations indicate that the tailings beach consists predominantly of tailings sand to depths on the order of 50 to 60 feet below the surface of the beach. Slime layers were encountered, however, at depths as shallow as 13 feet below the surface. The tailings sand is very loose to loose, medium- to fine-grained, and contains variable amounts of silts. The slime layers are as thick as five feet and consist of silt and clay with low to moderate plasticity. The layers are soft to medium stiff.

Below a depth of approximately 50 to 60 feet the materials encountered were predominantly slime tailings. The slimes are normally-consolidated to under-consolidated silt and clay of low to moderate plasticity and are very soft to stiff.

At the compacted tailings sand embankments now under construction, the sand fill is being placed by the upstream construction method in horizontal lifts. The sand is obtained from the tailings beach, and it is our understanding that the sand is compacted to at least 90 percent of maximum dry density as determined by ASTM Test Method D1557-78. In addition, the downstream slope of the completed sand fill is covered with a minimum of two feet of end-dumped mine waste material.

3.3 SEISMICITY

Earthquakes in Utah occur primarily within a 60- to 100-mile wide zone of the Southern Intermountain seismic belt that marks the transition between the Basin and Range province and the Colorado Plateau and Middle Rocky Mountain provinces. This earthquake zone trends north-south from the Utah-Idaho border to the area around Richfield and then changes to a southwest trend that extends across the Utah-Nevada border. The eastern edge of this seismic belt extends into the Uinta Basin about as far as Duchesne. The project area near Vernal is approximately 80 miles east of the main seismic belt. There have been low magnitude earthquakes reported northeast of Vernal, but all were measured at less than 4.0 on the Richter scale.

The project area falls in Seismic Zone I and has the potential for very low seismic activity, as indicated in both the Uniform Building Code and the Rules and Regulations Governing Dam Safety in Utah (Ref. 1 and 2). No major faults were seen in the project area during previous geologic reconnaissances.

The U.S. Corps of Engineers' recommended guidelines for safety inspection of dams (Ref. 3), indicates that the seismic coefficient for use in pseudo-static slope stability analyses should be 0.025 for projects located in the Seismic Zone 1. Therefore, this value was used in the stability analyses described in Section 4.2.

SECTION 4
ENGINEERING DESIGN STUDIES

4.1 HYDROLOGY AND FREEBOARD REQUIREMENTS

Because sufficient freeboard will be constantly maintained to fully contain run-off resulting from the probable maximum precipitation event, no operational spillway is planned for the construction period (approximately 20 years). However, for added safety, a final overflow spillway will be constructed 3 feet below the ultimate crest elevation of 5970 at one of several potential locations as shown in Figure 2. Final design of the overflow spillway will be accomplished at a later date. Flood routing analyses are not planned because adequate freeboard is to be provided to contain a probable maximum flood event without spilling. An area-capacity curve for the reservoir has been developed and is included in Figure 1.

The drainage area above the enlarged embankment was calculated to be 5.0 square miles. Following procedures outlined in Reference 4, the 24-hour probable maximum precipitation (PMP) event was estimated to be 9.45 inches. The surface soils in the project area were estimated to classify within Soil Conservation Service (SCS) hydrologic soil group C. This group is described as soils having slow infiltration rates when thoroughly wetted and consisting chiefly of soils with a layer that impedes downward movement of water, or soils with moderately fine to fine texture. The grass and brush coverage of the watershed area was estimated as poor to fair. For antecedent moisture condition III, the runoff curve number was estimated to be 91 (Reference 4). Using the estimated PMP and curve number, direct runoff was calculated to be 8.5 inches. Total runoff from the drainage area was calculated to be 2,300 acre-feet.

At the proposed final overflow spillway crest elevation of 5967 feet, the pond will have a total storage capacity of 27,200 acre-feet. Of this amount, 4,400 acre-feet have already been used for tailings storage, and 20,500 acre-feet is available for future storage of tailings. The remaining 2,300 acre-feet of capacity is needed to provide 7 feet of freeboard below the spillway crest in order to retain the runoff from the PMP without spilling. During construction (i.e., life of the pond operation), a minimum freeboard of 10 feet below the embankment crest will be maintained which will be adequate to retain the full PMP runoff without overtopping.

4.2 STABILITY ANALYSES

Slope stability studies were performed on two design cross-sections of the final enlarged embankment. Cross-sections C and F (shown in Figure 5) were selected for the analyses because these sections were judged to be the most critical from a stability standpoint due to their large heights and steeper slopes and the presence of relatively deep alluvial foundation soils. All other design cross-sections are expected to have higher factors of safety than those calculated in this study.

The material properties used in the stability analyses are presented in Table 1. The strength parameters for the natural foundation soils, slime tailings, and mine waste rock were based on our field and laboratory work and on the previous work by others (Section 1.3). The strength parameters in the tailings beach and zone of layered sand and slimes were based on published correlations with Standard Penetration blowcounts. The strength parameters for the compacted tailings sand were based on results of triaxial testing performed by MKE during a previous study.

TABLE 1

MATERIAL PROPERTIES FOR STABILITY ANALYSES

No.	Material Description	Friction Angle (degrees)	Cohesion (psf)	Unit Weight (pcf)
1	Existing Mine Waste Rock	40	0	130
2	Compacted Tailings Sand	33	0	125
3	Random Fill - Compacted Tailings Sand and Moenkopi Siltstone	28	200	125
4	Tailings (Mainly Slimes)	7.5	560	100
5	Tailings Sand and Slimes	28	0	120
6	Foundation Soil	30	0	120
7	Bedrock	45	10,000	145

The random fill material for construction of the dam will come from both tailings sand, mine-waste rock, and on-site Moenkopi formation. Strength parameters selected for the random fill zone are based on past experience and information from published literature (Ref. 5). In our selection we have conservatively assumed that the Moenkopi will break down into predominantly silt and clay size particles. Therefore, the strength parameters chosen for the random fill zone are relatively low and can be considered to be representative of a "worst-case" situation.

The analyses were accomplished using the computer program SLOPE which computes the factors of safety for specified slip circles by the Simplified Bishop Method. A seismic coefficient of 0.025 was used for the pseudo-static analyses.

The results of the analyses are shown graphically in Figures 9 and 10. For cross-section C, the minimum steady seepage and pseudo-static (seismic) safety factors are 1.53 and 1.41, respectively. For cross-section E, the minimum safety factors for these two cases are 1.55 and 1.44, respectively. These factors of safety are more than adequate and satisfy the Utah State Engineer's recommended criteria for slope stability (Reference 2).

4.3 INTERNAL DRAINAGE SYSTEM DESIGN

A. Description

The purpose of the internal drainage system is to intercept seepage from the tailings pond and to route the seepage safely through the dam and its foundation. The drains have been designed with ample capacity to convey the maximum seepage inflows from the tailings beach and foundation.

The proposed drainage system consists of a chimney drain, blanket drains, and collector drains. The plan location of blanket and collector drains is shown in Figure 6. The location of the chimney drain is shown in the embankment cross-sections of Figure 5, and miscellaneous drain details are presented in Figure 7. Each element of the drainage system is briefly described below.

The position of the chimney drain within the embankment varies along the embankment alignment (Figure 5). In the area where the embankment will be raised above the crest of the existing embankments or above the access road to the pond (cross-sections B, C, and D of Figure 5), the chimney drain will be brought up from the existing crest or access road, first vertically and then parallel to the upstream slope of the dam. In the remaining areas, the chimney drain will be brought up parallel to the upstream slope of the dam (cross-sections A, E, and F of Figure 5).

The chimney drain will discharge the seepage flow into collector drains running along its toe except where the embankment is built on the downstream slopes of the existing embankments. In these areas, the chimney drain will be tied to blanket drains covering the slopes, as shown by the shaded areas in Figure 6, and collector drains will be located at the downstream edge of the blanket drains.

The collector drains will transport the seepage flow across the dam foundation to the downstream toe of the embankment. Because collector drains have to convey concentrated flows along relatively gentle slopes, they will be provided with a core of very coarse, highly pervious, gravel material. The required core material gradation band is described in the Specifications.

A filter layer of compacted tailings sand will be provided betweeen the blanket drains and the downstream slopes of the existing embankments in order to prevent piping of pond slimes through the embankment rockfill and into the drain material (Figure 7, details 1, 3, 4, and 6). Likewise, two filter layers are required to separate the natural silty soils from the coarse-grained material in the collector drain cores (Figure 7, details 4 through 7). The outer filter layer will consist of compacted tailings sand, and the inner filter layer will consist of gravelly sand blanket-drain material. At the surfaces where the collector drains are in contact with embankment material (compacted sand tailings or rockfill) only the inner filter layer will be needed.

B. Design Methodology

The drains were designed to safely convey the maximum seepage flow through the embankment and dam foundation. The seepage flow was determined from the final maximum pond elevation 5960 feet by means of conventional flow net calculations. The maximum seepage quantity entering the drain system was calculated on the assumption that, during operations, a tailings sand beach at least 200 feet wide will be maintained between the embankment and the pool of free water. Average tailings beach permeability was estimated to be no greater than 5×10^{-4} centimeters per second on the basis of results of laboratory permeability tests performed by others. In addition, the assumption was made that operation of seepage collection systems downstream of the dam will not submerge the drains.

The maximum seepage flow rates collected at the toe of the embankment were estimated to be as follows:

Collection Area	Flow (gpm)
Northern Drainage Downstream of Tailings Dam No. 1	650
Middle Drainage Downstream of Secondary Dam	300
Southern Drainage Downstream of Main Dam	1,000

The capacities of the chimney drains, blanket drains, and collector drains were calculated by applying Darcy's Law. The minimum coefficient of permeability for the chimney and blanket drain material was estimated to be 0.1 centimeters per second for the specified gradation band. For the drain core material, the minimum coefficient of permeability was estimated to be 35 centimeters per second. The capacities of the collector drains were calculated on the basis of the minimum drain slopes specified in Figure 7.

The required drain cross sections were estimated using safety factors ranging from 5 to 10 to account for possible reductions in drain capacity due to turbulent flow effects and to minor localized changes in material gradations.

4.4 SITE PREPARATION

Site preparation should extend over the entire area to be covered by embankment fill or drain material and should consist of clearing, stripping, excavation, and foundation preparation, as discussed below.

All embankment subgrade areas should be kept well graded and drained; ponding of seepage water or storm runoff should not be allowed. All junipers, sage brush and other vegetation (including roots) should be cleared from all areas to be covered with fill or drain material. Grass, roots, and other deleterious materials should be stripped and disposed of in an acceptable manner. Stripped materials must not be used as fill in the embankment or drains. The depth of stripping should be determined in the field by a qualified engineer. Anticipated depths are 0 to 12 inches depending on the density of vegetation for all embankment foundation areas except the bottom of the northern and southern drainages.

More extensive foundation work will be required in the northern and southern drainages which contain the existing seepage collection ponds and are filled with soft, saturated alluvial soils. Prior to starting foundation preparation in these areas, it will be necessary to construct new seepage collection ponds downstream of the existing collection ponds. Design of these ponds was not included in this scope of work and will be performed by others. For illustrative purposes only, the conceptual layout of these ponds has been included in Figure 6.

After the new collection ponds are completed, the dikes forming the existing collection ponds should be removed and the ponds drained into the new ponds. In order to facilitate drainage, it may be necessary to excavate drainage trenches through the alluvial soils from the existing to the new collection ponds.

Once the existing ponds have been drained and have dried out sufficiently to allow access to earthmoving equipment, the very soft soils, deleterious materials and vegetation in the bottom of the drainage should be removed. If some areas remain too soft to allow access, a rock pad can be built by bulldozing mine waste rock or Moenkopi siltstone onto these areas. The depth of soft soils to be removed from the bottom of the drainages should be determined in the field by a qualified engineer. A rough estimate of the maximum depths of excavation is 10 to 15 feet in the northern drainage and 7 to 10 feet in the southern drainage. However, greater excavation depths may be required in localized areas.

After the drainages have been cleared of all unacceptably soft soils and deleterious materials, they should be brought up to the grades shown on Figure 6 with compacted fill. Moenkopi siltstone may be used as fill in this area; however, at least 4 feet immediately below the drain foundation should consist of mine-waste rock or sand tailings.

After stripping and excavating as required but prior to placing any fill or drain material, the exposed ground surface should be compacted as required by the Specifications to ensure adequate foundation strength.

Where embankment or drain materials will be placed on the existing embankments, only minor foundation preparation will be required. Large, open-graded, boulders greater than 18-inches should be removed from the existing embankments prior to placing compacted sand tailings. The boulders may be stock-piled for later use in the random fill embankment Zone 4 (Figure 5).

4.5 EMBANKMENT CONSTRUCTION MATERIALS

The embankment and drain system will be constructed with four different material types. Material descriptions and sources for each material type are discussed below.

A. Material Type 1

Material Type 1 will be used for the chimney and blanket drains and as a filter for the collector drains. This material should consist of durable gravelly sand and must be free of organics, oversized rocks and other deleterious materials. Gradation requirements for this material are given in the Specifications. These gradation requirements were developed using established filter criteria (Ref. 4). These criteria ensure that the material will be sufficiently fine to prevent piping of sand tailings into the drains but also sufficiently coarse so as to have a high enough permeability to function as an adequate drain. In addition, this material satisfies the filter criteria with respect to Material Type 2.

No material or blend of materials presently available at the site meets the gradation requirements for Material Type 1. Therefore, this drain material will be obtained from an off-site borrow source.

B. Material Type 2

Material Type 2, which will be used in the collector drains, consists of coarse gravels. The material should be durable and must be free of organics, oversized rocks and other deleterious materials. Gradation requirements for this material are given in the Specifications. The material as specified will be coarse enough to provide free drainage and also will satisfy filter criteria with respect to Material Type 1.

As for Material Type 1, no material or blend of materials presently available at the site will meet the gradation requirements for Material Type 2. Off-site commercial borrow sources are currently being investigated.

C. Material Type 3

Material Type 3 consists of compacted tailings sand produced as a waste product of the phosphate mill process. As described in Section 3, this material generally is fine grained sand with between 5 and 27 percent by weight finer than the No. 200 sieve. Sand tailings will be used for embankment construction in the zone upstream of the chimney drains and also will be placed as a filter below the blanket drains and collector drains.

The tailings sands are transported from the mill to the tailings pond via a slurry pipeline. The tailings are deposited into the pond from the embankment crest forming a tailings beach of variable width (approximately 200 to 500 feet). Tailings sand will be excavated from the beach and used for construction of the dam expansion.

A revision in the mill process is planned which will alter the gradation of the sand tailings. The exact revised gradation for the tailings is not known at this time. Since the required gradation of Material Type 1 has been developed to satisfy filter criteria with respect to the sand tailings, it may be necessary to revise the gradation requirements for Material Type 1 after the revision in the mill process has been accomplished.

D. Material Type 4

Material Type 4 is a random fill consisting of sand tailings, mine-waste rock, or Moenkopi siltstone and shale. This material should be used only downstream of the internal drainage system where the material will be isolated from pond seepage water. This material can also be used to fill the northern and southern drainages below the collector drains. As discussed in Section 4, however, only mine waste rock or sand tailings should be placed in the upper 4 feet of fill in those drainages below the collector drains.

The sand tailings have been described in paragraph C, above. The mine waste rock consists of predominantly hard limestone overburden materials from the phosphate mining operation. This material was used to construct the existing main and secondary dams of Tailings Pond No. 2 and Dam No. 1. Past experience indicates that the mine-waste rock will break down during transportation and compaction into fine to coarse gravel, cobbles, and boulders in a matrix of silty fine to coarse sand.

Since sufficient sand tailings will not be available in the quantities required for construction of the embankment enlargement, Moenkopi siltstone and shale and mine waste rock will also be used for Material Type 4. The potential borrow sources for the Moenkopi are located within the reservoir area as shown in Figure 2. Our field investigation found that in the borrow areas the Moenkopi consists generally of medium hard siltstone and sandstone with very thin lenses of gypsum. The overall gympsum content is estimated to be quite low, although a 2- to 8-foot-thick layer of intermixed gypsum and siltstone was found at approximately 26 foot depth. During excavation in the borrow areas, it will be necessary to reject any Moenkopi containing a significant proportion of gypsum.

Previous seismic surveys in the vicinity of the borrow areas found that the seismic velocity of the Moenkopi can be as high as 12,500 feet per second indicating that blasting may be required for excavation.

SECTION 5
INSTRUMENTATION AND MONITORING

5.1 GENERAL

As the tailings dam is being enlarged it is important to monitor its performance to ensure that the structure is functioning as designed. Additionally, it is important to monitor long term performance following completion of the project. A properly designed monitoring system will facilitate timely changes during operations, and may justify cost saving adjustments in later years. This monitoring system requires a carefully planned instrumentation installation and operation program to measure pore water pressures, settlements, movements and other key "vital signs." The instrumentation system planned for the tailings dam consists of stand-pipe piezometers, displacement markers and weirs as described below.

5.2 PIEZOMETERS

In order to monitor the performance of the internal drainage system, three stand-pipe piezometers will be installed at the locations and elevations shown in Figure 8 when the dam crest reaches elevation 5900 feet. As the embankment is enlarged, the outer protective metal pipe and PVC pipe will be extended in stages. Care will have to be exercised to protect the piezometers as much as possible during the placement of embankment fill, and damaged or malfunctioning piezometers should be replaced.

Immediately after installation, each piezometer should be tested and the water elevation should be read and recorded. Thereafter, we recommend that the water surface elevation in the piezometers be measured and recorded at least each month. More frequent measurements should be made if anomolous readings or sudden changes in readings occur which might signal the possibility of an internal drainage problem in the embankment.

5.3 DISPLACEMENT MARKERS

Because the dam embankment will be raised in successive stages, the crest alignment will vary accordingly. As the dam is enlarged, a system of displacement markers will be established both along the crest of the dam and on the downstream slope of the embankment. The markers will be located as follows:

- One displacement marker per 100 feet along the crest line.
- One displacement marker per 100,000 square feet of downstream dam surface.

As new embankment fill is placed, the markers will be removed and replaced. The system will be correlated with established reference points consisting of on-site bench marks outside of the final embankment downstream toe line.

Elevations and coordinates of measurement points should be read immediately after the markers are established. At other times measurement points should be read either monthly or more often if required.

5.4 SEEPAGE MEASURING WEIRS

In order to measure seepage flow rates through the internal drainage system, seepage measuring V-notch weirs will be constructed downstream of the embankment at the approximate locations shown on Figure 8. The exact location of the weirs will be determined in the field.

A schematic diagram of the weir is shown in Figure 8 along with the corresponding weir rating curve. We recommend that flow rates be measured and recorded every week, although measurements should be made more often if sudden changes in seepage flow are observed.

SECTION 6
REFERENCES

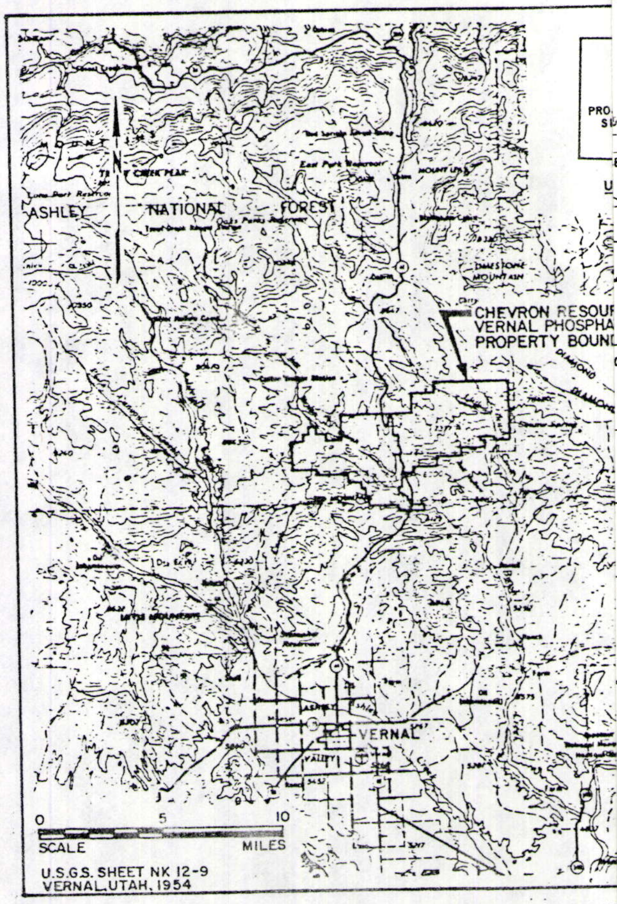
1. International Conference of Building Officials, Uniform Building Code, 1982.

2. Utah State Division of Water Rights, "Rules and Regulations Governing Dam Safety in Utah," January, 1982.

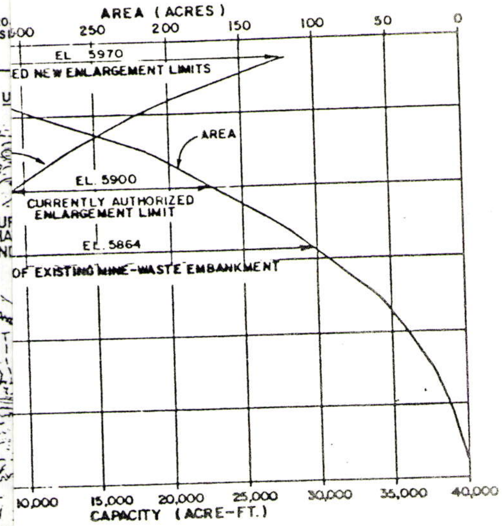
3. U.S. Army Corps of Engineers, "Recommended Guidelines for Safety Inspection of Dams, Appendix D," 1977.

4. U.S. Department of the Interior, Bureau of Reclamation, Design of Small Dams, 1977.

5. Federal Highway Administration, "Design and Construction of Compacted Shale Embankments, Vol. 1, Survey of Problem Areas and Current Practices," Report No. FHWA-RD-75-61, August 1975.



PROJECT LOCATION



AREA-CAPACITY CURVE

M

VEN

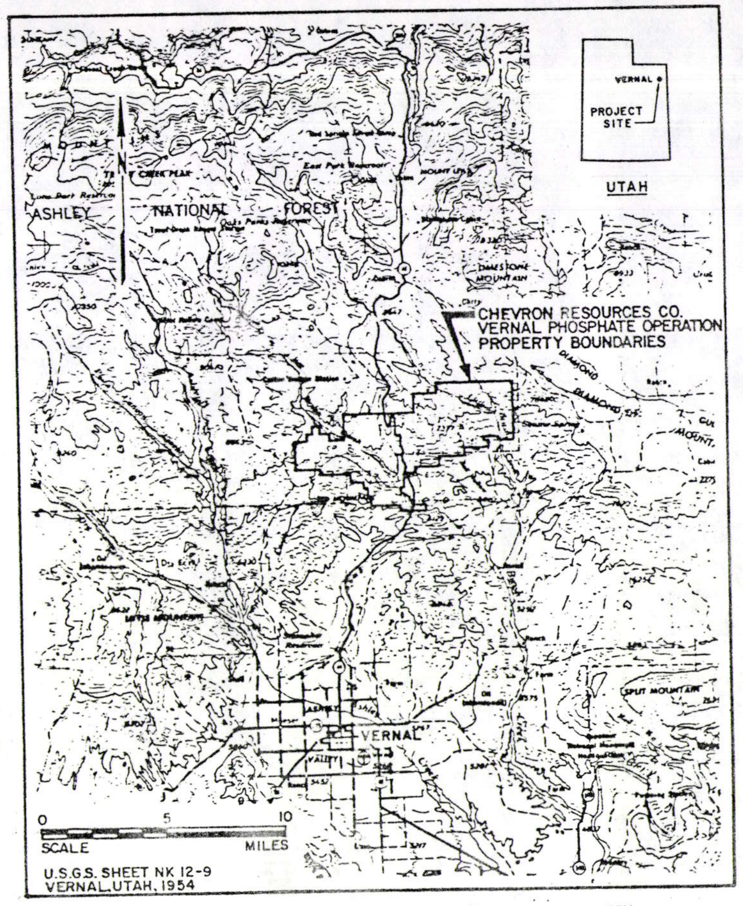
AILINGS

NO.	DATE
1	5-14-85
0	4-30-85

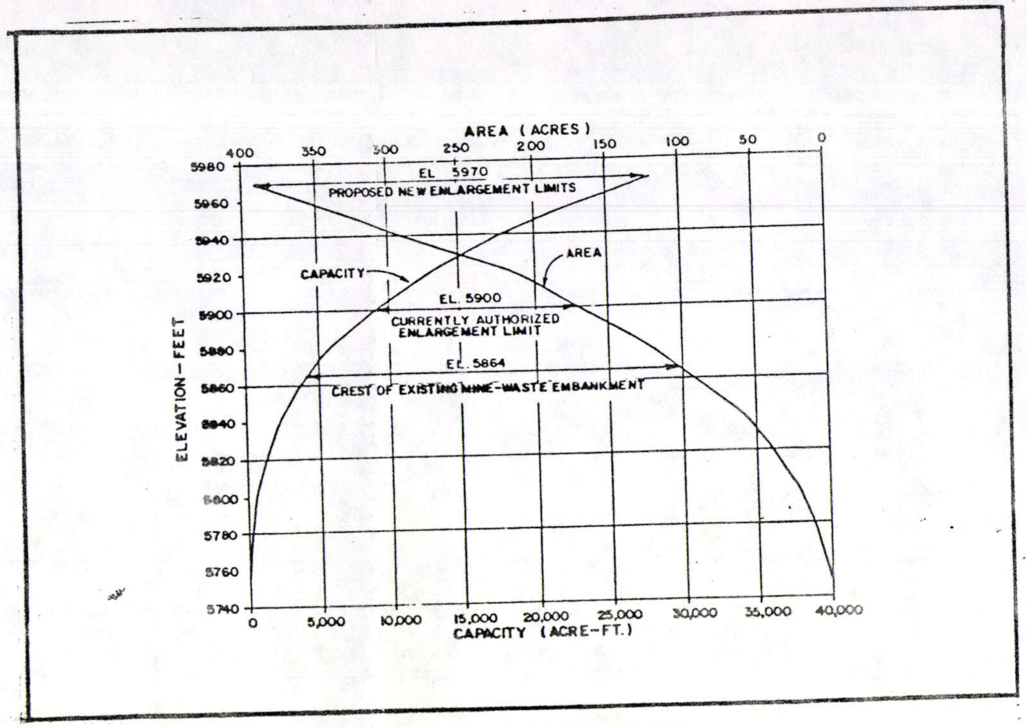
COVER SHEET, PROJECT LOCATION
& AREA-CAPACITY CURVE

IECO NO.		
2151D - DG1		
SHEET 1	OF 8	REV. 1

FIGURE 1



PROJECT LOCATION



AREA-CAPACITY CURVE

DRAWING INDEX	
FIGURE	SUBJECT
1	COVER SHEET, PROJECT LOCATION & AREA-CAPACITY CURVE
2	TOPOGRAPHY, SURVEY DATA & EMBANKMENT LAYOUT
3	GEOLOGIC PLAN
4	GEOLOGIC PROFILES
5	DAM CROSS-SECTIONS
6	DRAINAGE SYSTEM PLAN AND PROFILE
7	MISCELLANEOUS DETAILS
8	INSTRUMENTATION PLAN AND PROFILE

CHEVRON RESOURCES COMPANY

APPROVED AND ACCEPTED THIS 9th DAY OF August 1985.

Thomas M. Anderson

CERTIFICATE OF ACCEPTANCE

CHEVRON RESOURCES COMPANY CERTIFIES THAT IT HAS EMPLOYED MORRISON-KNUDSEN ENGINEERS, INC., FORMERLY INTERNATIONAL ENGINEERING CO., INC., TO PREPARE THE ACCOMPANYING DRAWINGS AND SPECIFICATIONS FOR THE CONSTRUCTION OF THE VERNAL PHOSPHATE TAILINGS DAM AND THAT IT ACCEPTS THESE DRAWINGS AND SPECIFICATIONS.

Thomas M. Anderson

CERTIFICATE OF ENGINEER

I DO HEREBY CERTIFY THAT THESE PLANS FOR THE CONSTRUCTION OF THE VERNAL PHOSPHATE TAILINGS DAM WERE PREPARED BY ME FOR THE OWNERS THEREOF.

E. S. Smith. — ENGINEER

9 Aug., '85 — DATE

PROFESSIONAL LICENSE NO. 4719 UTAH

STATE ENGINEERS APPROVAL

IN ACCORDANCE WITH SECTION 73-5-5 UTAH CODE ANNOTATED 1953, AS AMENDED, APPROVAL IS HEREBY GIVEN FOR THE CONSTRUCTION OF THE VERNAL PHOSPHATE TAILINGS DAM.

STATE ENGINEER

NO.	DATE	REVISIONS	BY	CHK.	APP'D.
1	5-14-85	ISSUED FOR APPROVAL	CEB	PKC	PMG
0	4-30-85	ISSUED FOR REVIEW AND COMMENT	JDL	PKC	PMG

CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
A MORRISON-KNUDSEN COMPANY
180 HOWARD STREET, SAN FRANCISCO, CALIFORNIA 94105

DESIGNED JDL | DRAWN RBC | CHECKED PKC | RECOMMENDED PKC | APPROVED PMG | DATE APRIL 1985

CHEVRON RESOURCES COMPANY
VERNAL PHOSPHATE PROJECT

COVER SHEET, PROJECT LOCATION & AREA-CAPACITY CURVE

IECO NO. 2151D - DG1
SHEET 1 OF 8 REV. 1
FIGURE 1

NO.	DATE	REVISIONS	BY	CHK.	APP'D.
2	8-6-85	REVISED-RE-ISSUED FOR APPROVAL	CEB	GGC	PKC
1	5-14-85	ISSUED FOR APPROVAL	CEB	PKC	PMG
0	4-30-85	ISSUED FOR REVIEW AND COMMENT	CEB	PKC	PMG

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INTERNATIONAL ENGINEERING COMPANY, INC.
180 HOWARD STREET, SAN FRANCISCO, CALIFORNIA 94105

DESIGNED CEB | DRAWN RBC | CHECKED PKC | RECOMMENDED PKC
DATE APRIL 30, 1985 | APPROVED PMG

CHEVRON RESOURCES COMPANY
VERNAL PHOSPHATE PROJECT

TOPOGRAPHY, SURVEY DATA
& EMBANKMENT LAYOUT

ECO NO. 2151D' - DG1
SHEET 2 OF 8 REV. 1

FIGURE 2

200 0 200 400 600
SCALE FEET

1	5-14-85	ISSUED FOR APPROVAL	CEB	PKC	PMG
0	4-30-85	ISSUED FOR REVIEW AND COMMENT	JDL	PKC	PMG
		REVISIONS	BY	CHK	APP'D

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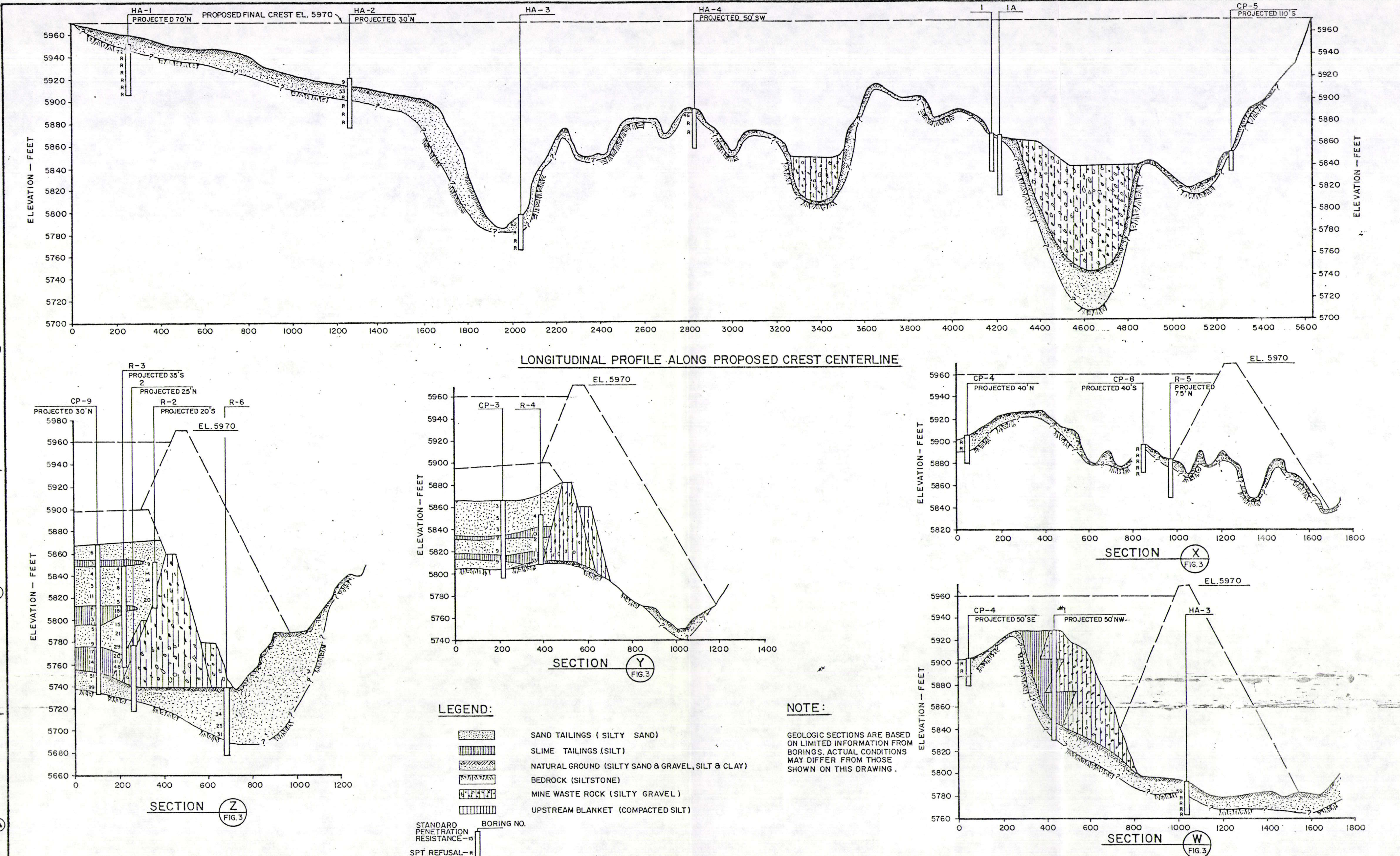
VERNAL PHOSPHATE PROJECT

GEOLOGIC PLAN

ECO NO. 2151D – DG1
SHEET 3 OF 8 REV. 1

FIGURE 3



NOTE:

GEOLOGIC SECTIONS ARE BASED ON LIMITED INFORMATION FROM BORINGS. ACTUAL CONDITIONS MAY DIFFER FROM THOSE SHOWN ON THIS DRAWING.

HORIZONTAL SCALE 200 0 200 400 FEET

VERTICAL SCALE 40 0 40 80 FEET

NO.	DATE	REVISIONS	BY	CHK.	APPD.
1	5-14-85	ISSUED FOR APPROVAL	ASC	PKC	PMG
0	4-30-85	ISSUED FOR REVIEW AND COMMENT	JDL	PKC	PMG

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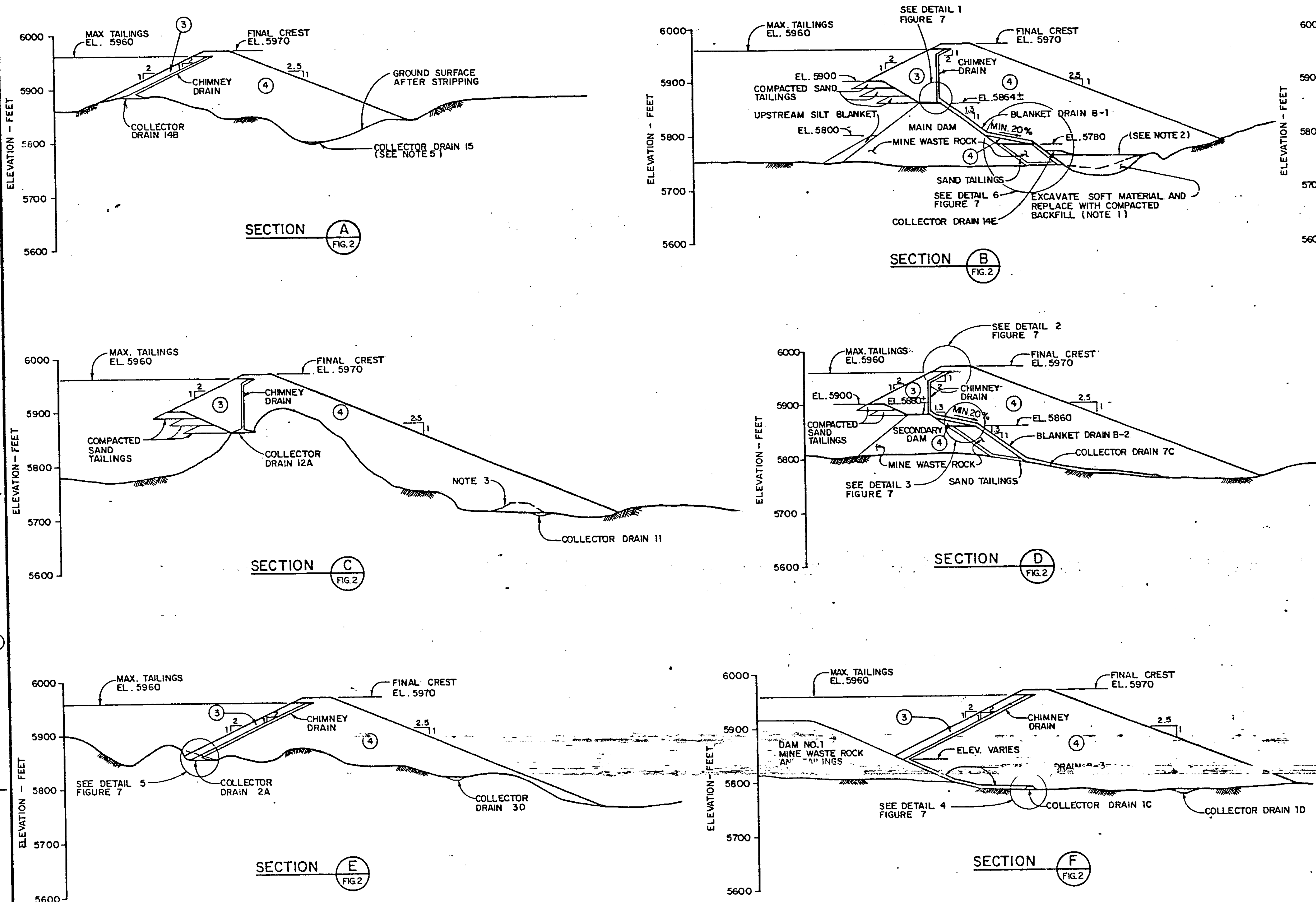
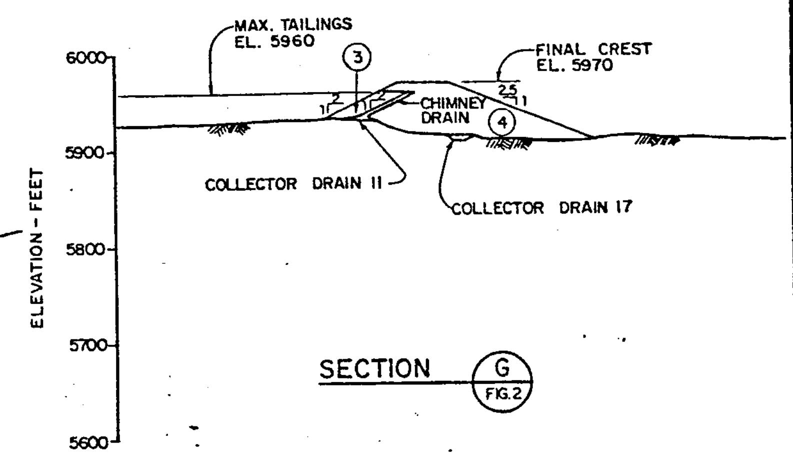
CHEVRON RESOURCES COMPANY
VERNAL PHOSPHATE PROJECT

GEOLOGIC PROFILES

IECO NO. 2151D – DG1
SHEET 4 OF 8 REV. 1
FIGURE 4





NOTES:

1. DEPTH OF EXCAVATION SHALL BE DETERMINED IN THE FIELD.
2. PLACE COMPACTED FILL TO GRADE AS SHOWN IN FIGURE 6.
3. REMOVE EXISTING DIKES AND DRAIN EXISTING SEEPAGE COLLECTION PONDS PRIOR TO PLACEMENT OF FILL.
4. SEE FIGURE 7 FOR LOCATION OF DRAIN MATERIALS 1 AND 2.
5. SEE FIGURE 6 FOR COLLECTOR AND BLANKET DRAIN LAYOUT.

MATERIAL TYPES	
SYMBOL	DESCRIPTION
1	DRAIN MATERIAL 1 - GRAVELLY SAND (SEE NOTE 4)
2	DRAIN MATERIAL 2 - GRAVEL (SEE NOTE 4)
3	COMPACTED TAILINGS SAND
4	RANDOM FILL - COMPACTED TAILINGS SAND OR MOENKOPI SILTSTONE

SCALE 100 0 100 200 300 FEET

NO.	DATE	REVISIONS	BY	CHK.	APPD.
2	8-6-85	REVISED - RE-ISSUED FOR APPROVAL	CEB	GGC	PKC
1	5-14-85	ISSUED FOR APPROVAL	CEB	PKC	PMG
0	4-30-85	ISSUED FOR REVIEW AND COMMENT	CEB	MPF	PMG

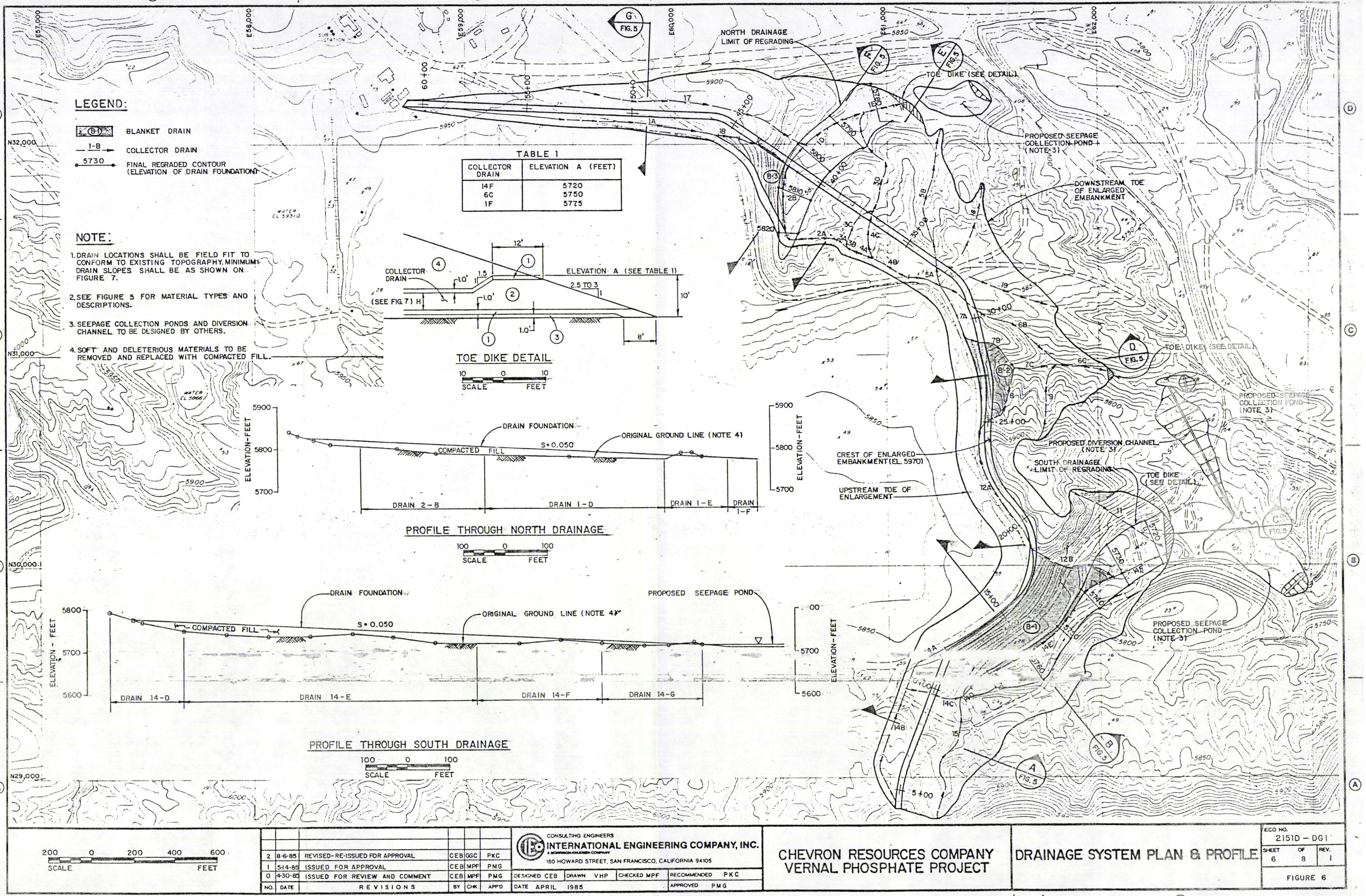
CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
180 HOWARD STREET, SAN FRANCISCO, CALIFORNIA 94105

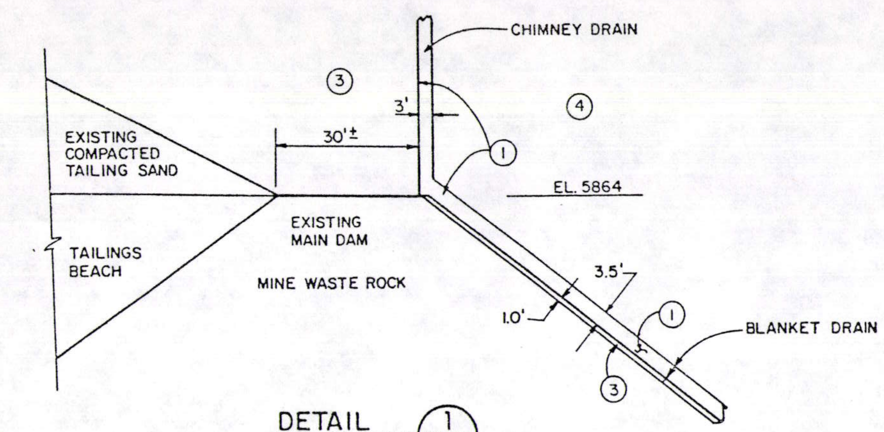
DESIGNED CEB | DRAWN VHP | CHECKED MPF | RECOMMENDED PKC
DATE APRIL 1985 | APPROVED PMG

CHEVRON RESOURCES COMPANY
VERNAL PHOSPHATE PROJECT

DAM CROSS - SECTIONS

IECO NO. 2151D - DG1
SHEET 5 OF 8 REV. 1
FIGURE 5

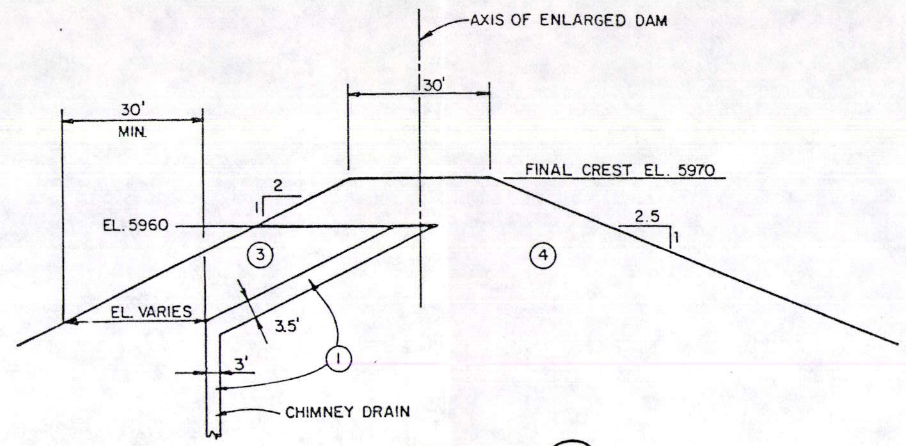

LEGEND:
B-1 BLANKET DRAIN
1-B COLLECTOR DRAIN
5730 FINAL REGRADED CONTOUR (ELEVATION OF DRAIN FOUNDATION)
NOTE:
1. DRAIN LOCATIONS SHALL BE FIELD FIT TO CONFORM TO EXISTING TOPOGRAPHY. MINIMUM DRAIN SLOPES SHALL BE AS SHOWN ON FIGURE 7.
2. SEE FIGURE 5 FOR MATERIAL TYPES AND DESCRIPTIONS.
3. SEEPAGE COLLECTION PONDS AND DIVERSION CHANNEL TO BE DESIGNED BY OTHERS.
4. SOFT AND DELETERIOUS MATERIALS TO BE REMOVED AND REPLACED WITH COMPACTED FILL.
TABLE 1
COLLECTOR DRAIN
ELEVATION A (FEET)
14F 5720
6C 5750
1F 5775
COLLECTOR DRAIN
(SEE FIG. 7) H
ELEVATION A (SEE TABLE 1)
12'
1.5
1
2.5 TO 3
1
10'
8'
1.0'
TOE DIKE DETAIL
SCALE
FEET
DRAIN FOUNDATION
ORIGINAL GROUND LINE (NOTE 4)
COMPACTED FILL
S = 0.050
ELEVATION-FEET
5900
5800
5700
DRAIN 2-B
DRAIN 1-D
DRAIN 1-E
DRAIN 1-F
PROFILE THROUGH NORTH DRAINAGE
PROPOSED SEEPAGE POND
DRAIN 14-D
DRAIN 14-E
DRAIN 14-F
DRAIN 14-G
5600
PROFILE THROUGH SOUTH DRAINAGE
NORTH DRAINAGE LIMIT OF REGRADING
TOE DIKE (SEE DETAIL)
PROPOSED SEEPAGE COLLECTION POND (NOTE 3)
DOWNSTREAM TOE OF ENLARGED EMBANKMENT
TOE DIKE (SEE DETAIL)
PROPOSED DIVERSION CHANNEL (NOTE 3)
SOUTH DRAINAGE LIMIT OF REGRADING
CREST OF ENLARGED EMBANKMENT (EL. 5970)
UPSTREAM TOE OF ENLARGEMENT
FIG. 5
N32,000
N31,000
N30,000
N29,000
E57,000
E58,000
E59,000
E60,000
E61,000
E62,000
E63,000
60+00
55+00
50+00
45+00
40+00
35+00
30+00
25+00
20+00
15+00
5+00
200 0 200 400 600
SCALE FEET
2 8-6-85 REVISED-RE-ISSUED FOR APPROVAL CEB GGC PKC
1 5-14-85 ISSUED FOR APPROVAL CEB MPF PMG
0 4-30-85 ISSUED FOR REVIEW AND COMMENT CEB MPF PMG
NO. DATE REVISIONS BY CHK APP'D
CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
180 HOWARD STREET, SAN FRANCISCO, CALIFORNIA 94105
DESIGNED CEB DRAWN VHP CHECKED MPF RECOMMENDED PKC
DATE APRIL 1985 APPROVED PMG
CHEVRON RESOURCES COMPANY
VERNAL PHOSPHATE PROJECT
DRAINAGE SYSTEM PLAN & PROFILE
ECO NO. 2151D - DG1
SHEET 6 OF 8 REV. 1
FIGURE 6



DETAIL 1 FIG.5

TYPICAL CONNECTION BETWEEN CHIMNEY DRAIN AND BLANKET DRAIN

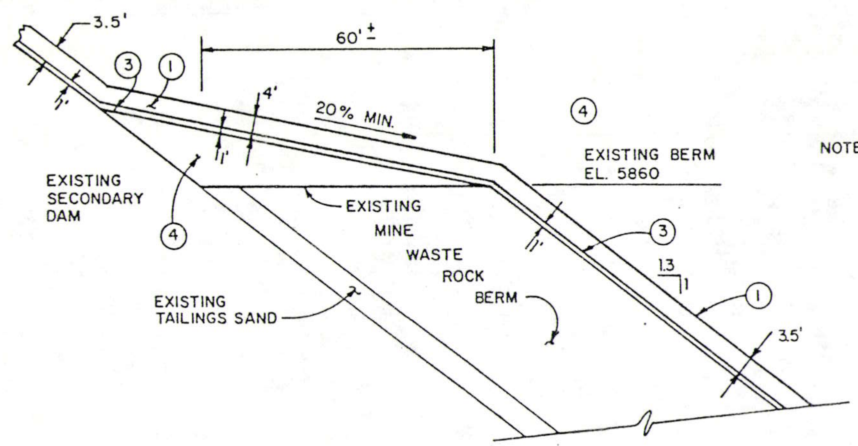
20 0 20
SCALE FEET



DETAIL 2 FIG.5

TYPICAL CREST DETAIL.

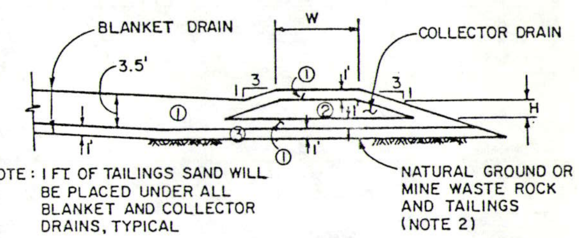
20 0 20
SCALE FEET



DETAIL 3 FIG.5

TYPICAL BLANKET DRAIN DETAIL

20 0 20
SCALE FEET

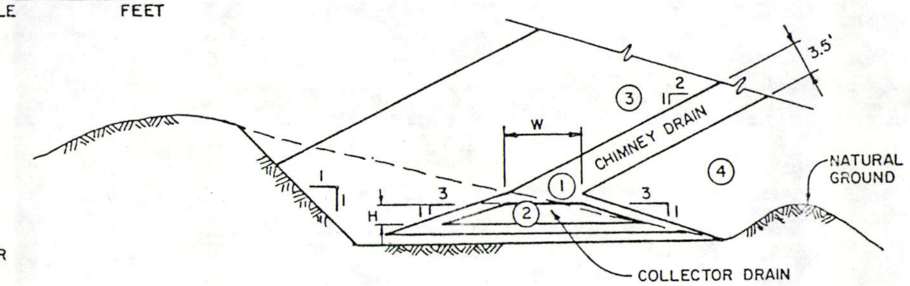


NOTE: I FT OF TAILINGS SAND WILL BE PLACED UNDER ALL BLANKET AND COLLECTOR DRAINS, TYPICAL

DETAIL 4 FIG.5

TYPICAL CONNECTION BETWEEN BLANKET DRAIN AND COLLECTOR DRAIN

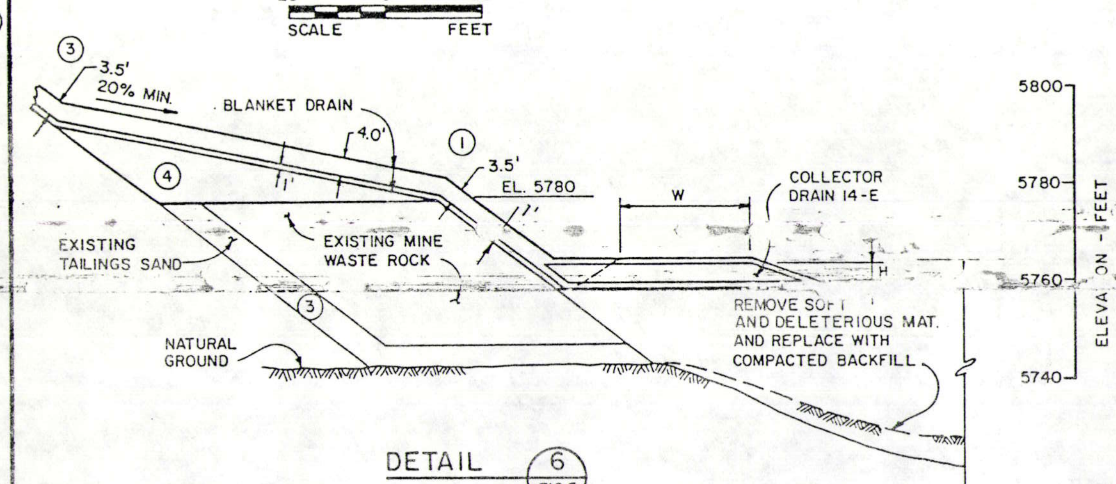
10 0 10
SCALE FEET



DETAIL 5 FIG.5

TYPICAL CONNECTION BETWEEN CHIMNEY DRAIN AND COLLECTOR DRAIN

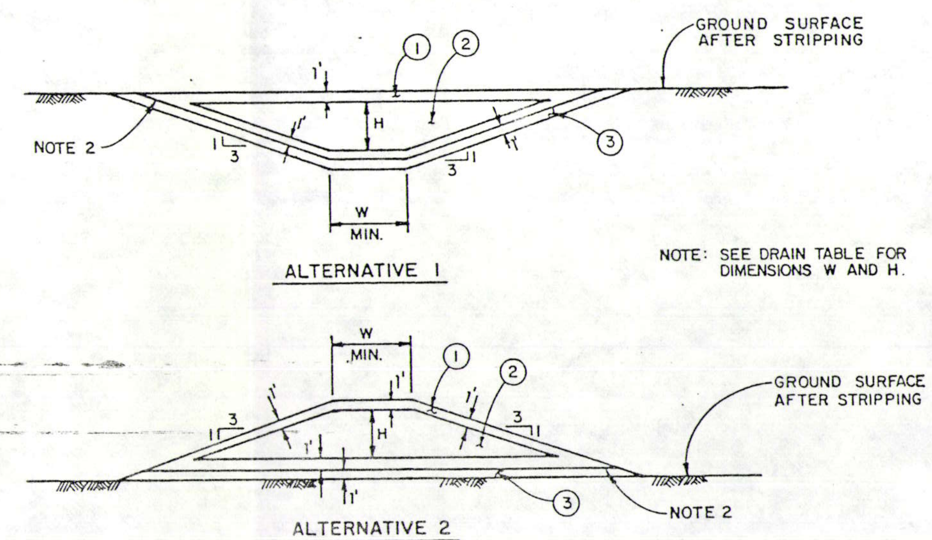
10 0 10
SCALE FEET



DETAIL 6 FIG.5

CONNECTING BLANKET DRAIN AND COLLECTOR DRAIN 14-E

20 0 20
SCALE FEET



NOTE: SEE DRAIN TABLE FOR DIMENSIONS W AND H.

DETAIL 7 FIG.6

TYPICAL COLLECTOR DRAIN DETAIL

10 0 10
SCALE FEET

DRAIN TABLE

DRAIN SECTION	MINIMUM DRAIN SLOPE	W (FT.)	H (FT.)	MIN. DRAIN AREA (FT.^{2})
1-A	0.017	17	3	78
1-B	0.25	8	2	28
1-C	0.37	8	2	28
1-D	0.050	34	3	129
1-E	0.050	34	3	129
1-F	0.050	34	3	129
2-A	0.20	8	2	28
2-B	0.050	34	3	129
3-A	0.37	8	2	28
3-B	0.31	8	2	28
3-C	0.10	8	2	28
3-D	0.083	8	2	28
4-A	0.10	8	2	28
4-B	0.07	8	2	28
4-C	0.083	8	2	28
5-A	0.025	10	2	31
5-B	0.054	8	2	28
6-B	0.20	8	2	28
6-C	0.067	8	3	52
7-A	0.025	8	3	49
7-B	0.143	8	3	49
7-C	0.133	8	3	49
8	0.133	8	2	28
9	0.25	8	2	28
11	0.37	8	2	28
12-A	0.020	16	4	111
12-B	0.37	8	2	28
13	0.45	8	2	28
14-A	0.045	14	3	68
14-B	0.071	8	3	47
14-C	0.125	8	3	51
14-D	0.050	22	4	136
14-E	0.050	27	4	153
14-F	0.050	41	4	209
15	0.040	8	2	28
17	0.033	8	2	28
18	0.10	8	2	28
19	0.10	8	2	28

NOTES:

(1) SEE FIGURE 5 FOR MATERIAL TYPES AND DESCRIPTIONS.

(2) MATERIAL 3 SHALL BE USED WHEREVER DRAINS WILL BE FOUNDED ON NATURAL SOILS. OMIT MATERIAL 3 WHERE COLLECTOR DRAIN IS PLACED ON COMPACTED ROCKFILL OR TAILINGS SAND.

NO.	DATE	REVISIONS	BY	CHK	APP'D.
2	8-6-85	REVISED-RE-ISSUED FOR APPROVAL	CEB	GGC	PKC
1	5-14-85	ISSUED FOR APPROVAL	CEB	MPF	PMG
0	4-30-85	ISSUED FOR REVIEW AND COMMENTS	CEB	MPF	PMG

CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
A MORRISON-KNUDSEN COMPANY
180 HOWARD STREET, SAN FRANCISCO, CALIFORNIA 94105

DESIGNED CEB | DRAWN DHW | CHECKED MPF | RECOMMENDED PKC
DATE APRIL 1985 | APPROVED PMG

CHEVRON RESOURCES COMPANY
VERNAL PHOSPHATE PROJECT

MISCELLANEOUS DETAILS

IECO NO. 2151D - DG1
SHEET 7 OF 8 REV. 1

FIGURE 7

LEGEND:

- (II) WEIR LOCATION
- [2] PIEZOMETER LOCATION WITH CREST EL. 5900
- ⟨5⟩ PIEZOMETER LOCATION WITH CREST EL. 5930
- (1) MATERIAL TYPE (SEE FIGURE 5 FOR DESCRIPTION)

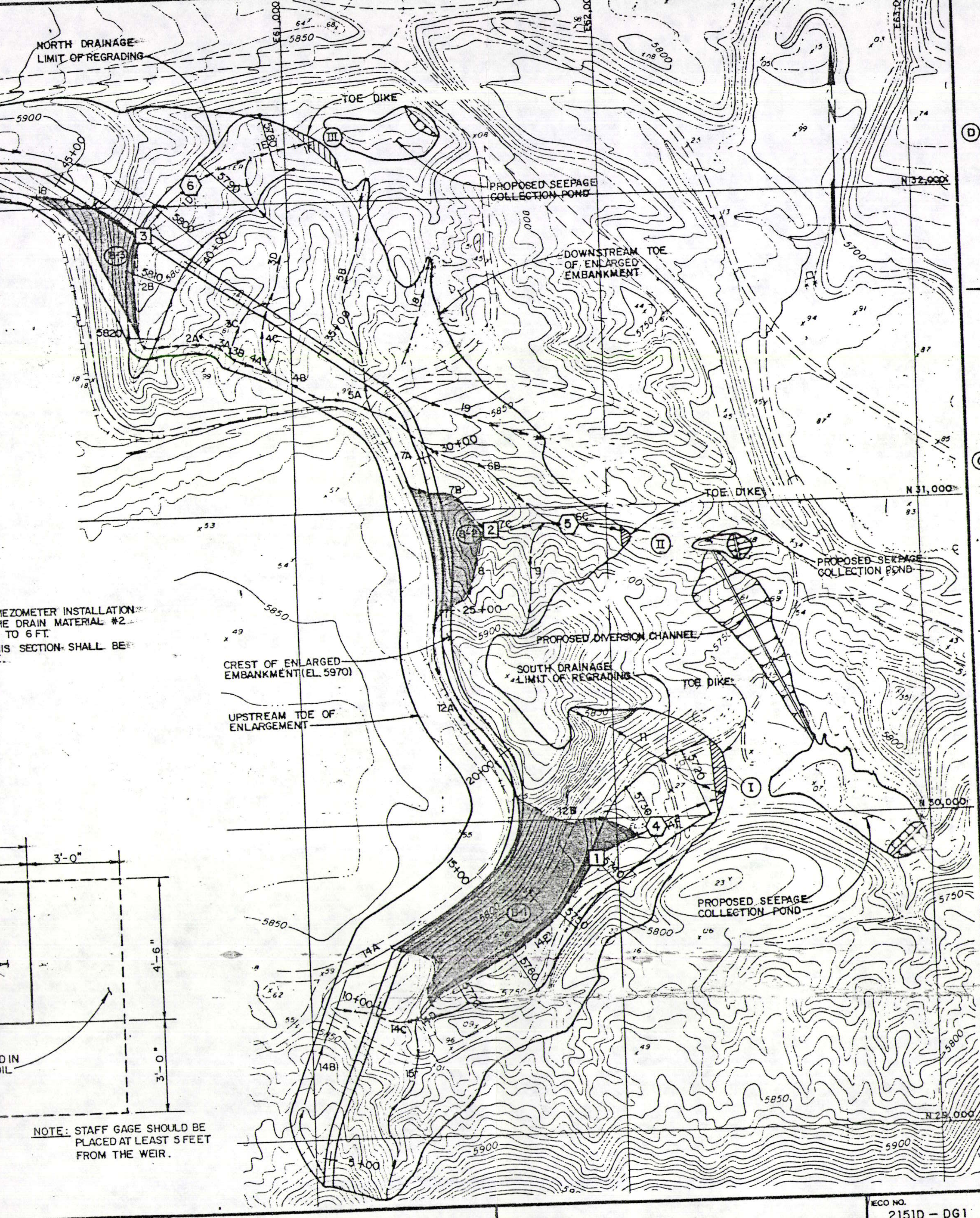
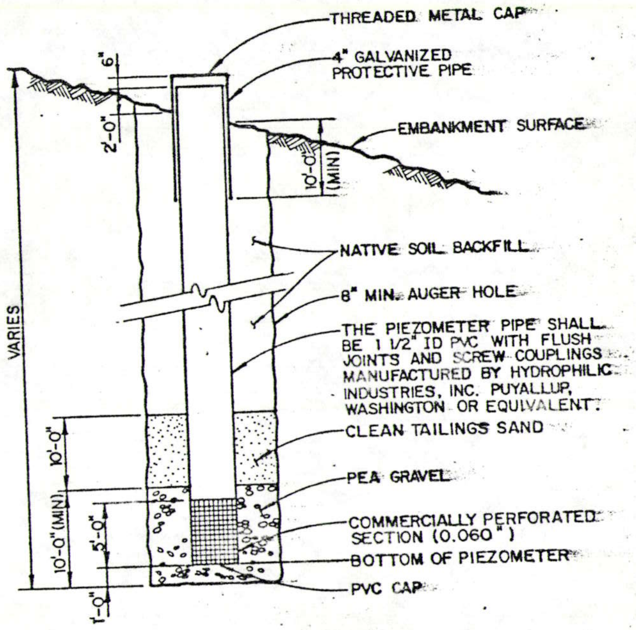


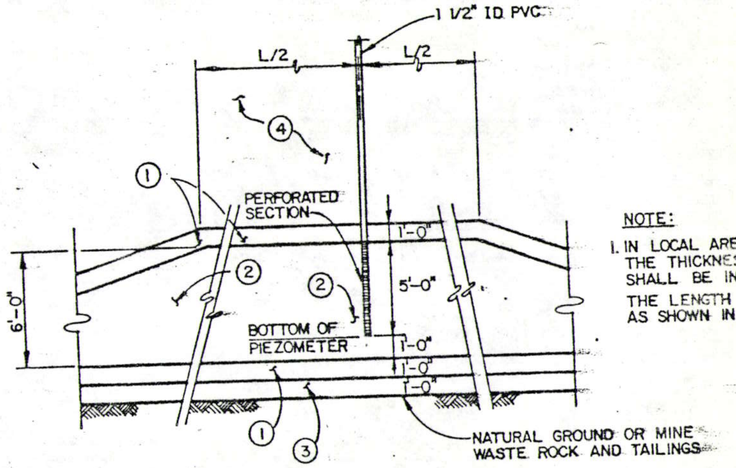
TABLE I

PIEZOMETER	L(FT.)	TIP ELEVATION
[1]	16	5743
[2]	8	DETERMINE IN FIELD
[3]	16	5808
⟨4⟩	20	5732
⟨5⟩	8	DETERMINE IN FIELD
⟨6⟩	20	5796



STANDPIPE PIEZOMETER DETAIL

NOT TO SCALE

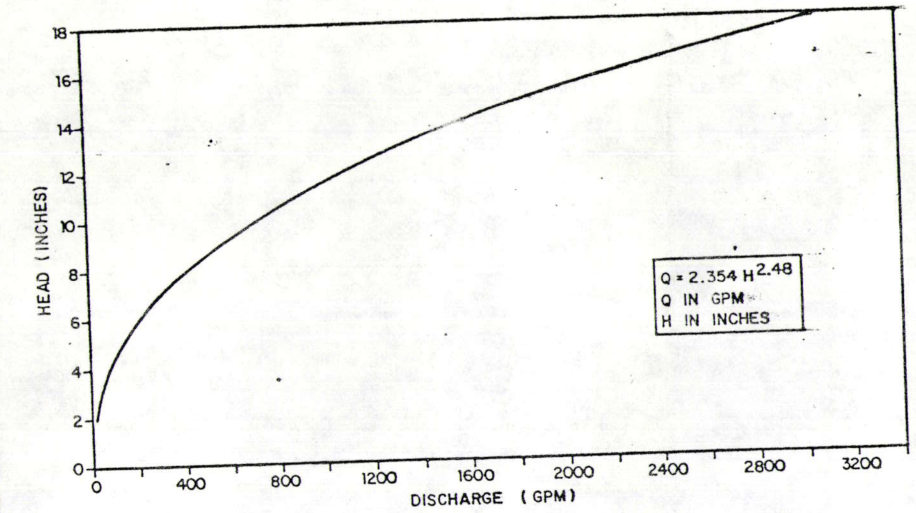


DRAIN DETAIL AT PIEZOMETER LOCATIONS

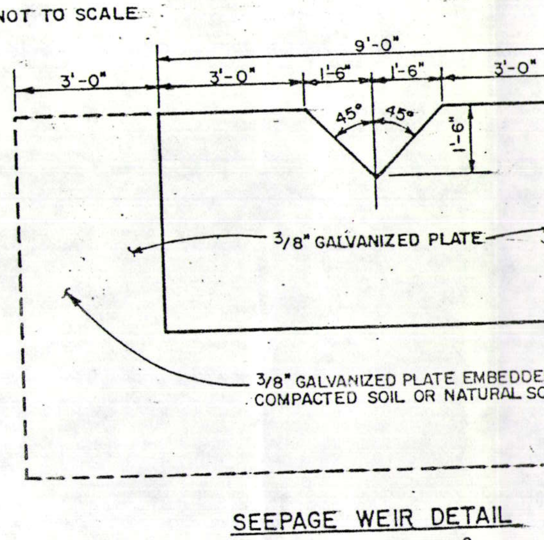
NOT TO SCALE

NOTE:

1. IN LOCAL AREAS OF PIEZOMETER INSTALLATION THE THICKNESS OF THE DRAIN MATERIAL #2 SHALL BE INCREASED TO 6 FT. THE LENGTH L OF THIS SECTION SHALL BE AS SHOWN IN TABLE I.



SEEPAGE WEIR DISCHARGE RATING CURVE



SEEPAGE WEIR DETAIL

SCALE 2 0 2 FEET

NOTE: STAFF GAGE SHOULD BE PLACED AT LEAST 5 FEET FROM THE WEIR.

SCALE 200 0 200 400 600 FEET

NO.	DATE	REVISIONS	BY	CHK.	APPD.
2	8-6-85	REVISED-RE-ISSUED FOR APPROVAL	CEB	GOC	PKC
1	5-14-85	ISSUED FOR APPROVAL	ASC	NPF	PMG
0	5-9-85	ISSUED FOR REVIEW AND COMMENT	ASC	MPF	PMG

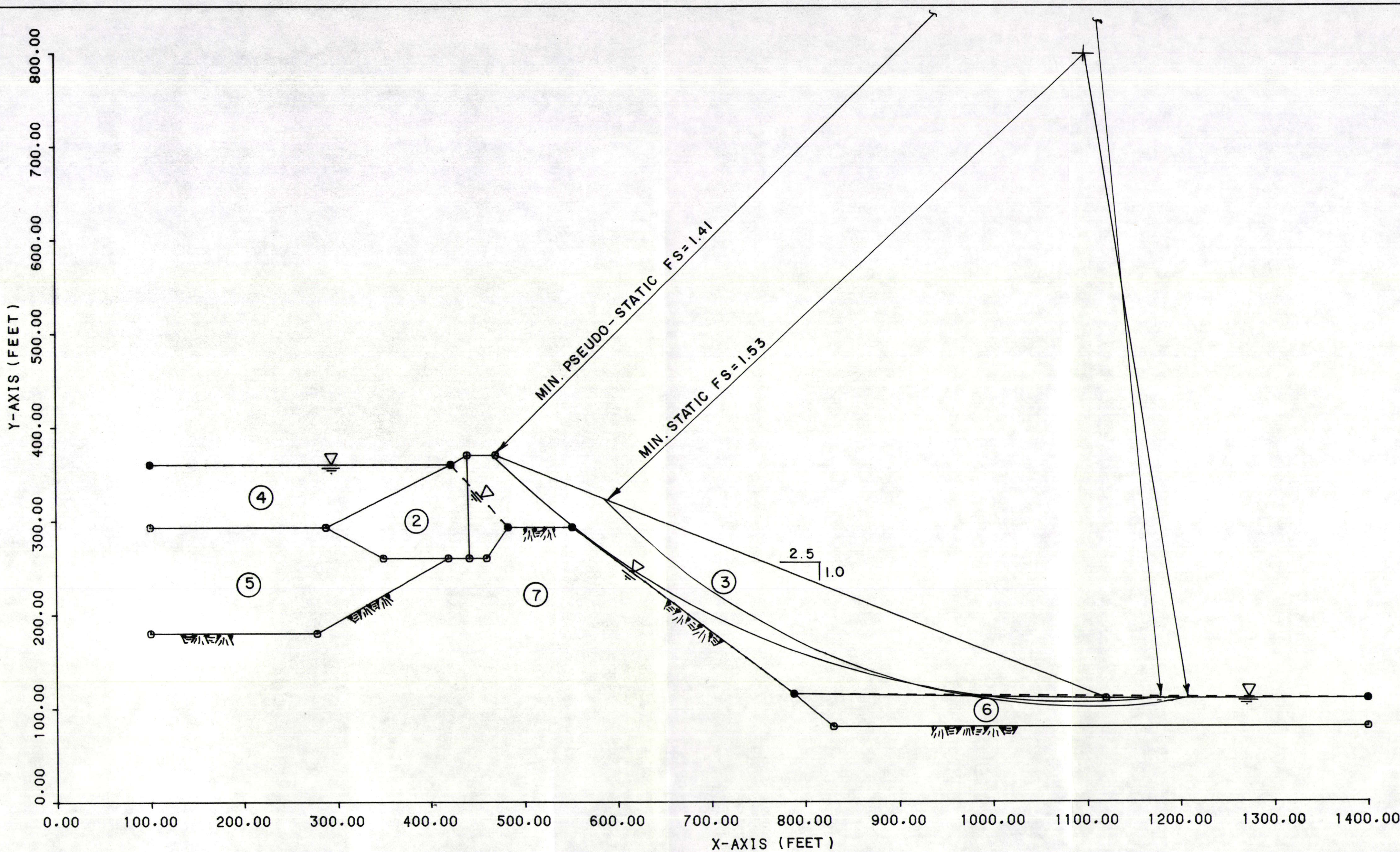
CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
180 HOWARD STREET, SAN FRANCISCO, CALIFORNIA 94105

DESIGNED ASC | DRAWN CCR/VHP | CHECKED MPF | RECOMMENDED PKC
DATE APRIL 1985 | APPROVED PMG

CHEVRON RESOURCES COMPANY
VERNAL PHOSPHATE PROJECT

INSTRUMENTATION PLAN & DETAILS

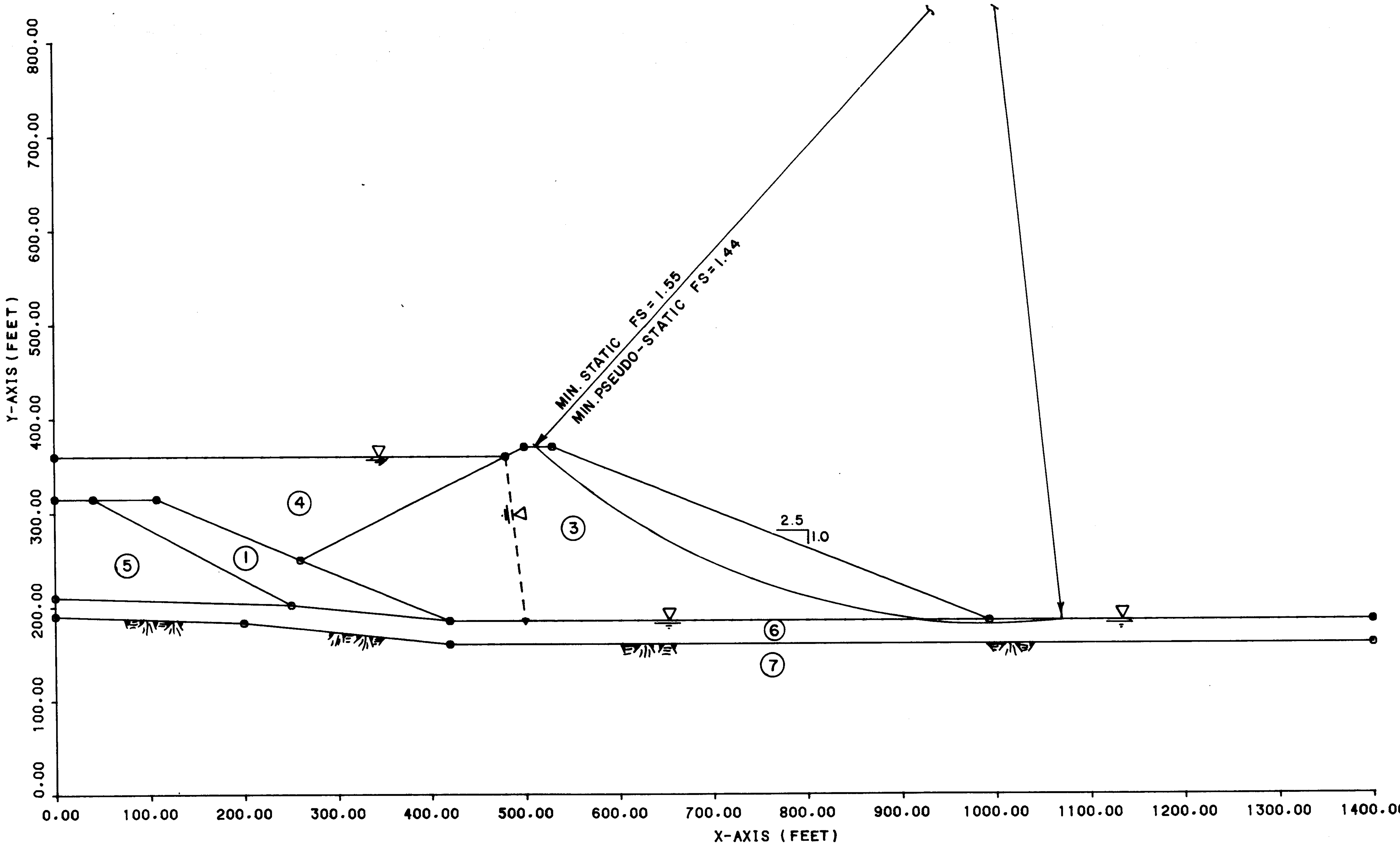
ECO NO. 2151D – DG1
SHEET 8 OF 8 REV. 1
FIGURE 8



IECO SLOPE PROFILE

SEE TABLE 1 FOR MATERIAL PROPERTIES (PAGE 4-3)

RESULTS OF STABILITY ANALYSIS
SECTION C



IECO SLOPE PROFILE

SEE TABLE 1 FOR MATERIAL PROPERTIES (PAGE 4-3)

RESULTS OF STABILITY ANALYSIS
SECTION F

APPENDIX A
BOREHOLE LOGS

INTERNATIONAL ENGINEERING CO., INC. SHEET 1 OF 2

DRILL LOG

PROJECT: CHEVRON PHOSPHATE		JOB NO.: 2151	HOLE NO.: HA-1
SITE: TAILINGS DAM EXPANSION	BEGUN: 10.0 AM 4-9-85	COMPLETED: 2.0 PM 4-9-85	HOLE SIZE: 7 3/4
ANGLE FROM HORIZ. & BEARING: VERT.			
COORDINATES: 32128.3 N - 59068.4 E	DEPTH/EL. GROUND WATER: NO WATER	GROUND EL.: 5951.0	DEPTH/~~EL.~~ TOP OF ROCK: 13 ±
DRILLING CONTRACTOR: ERICKSON - FORD	CORE RECOV. LENGTH/%: N/A	SAMPLES: 6	CORE BOXES: N/A
DEPTH/EL. BOTTOM OF HOLE: 45.1			
DRILL MAKE AND MODEL: CME 55	LOGGED BY: A.S. CHRISTENSEN		

TYPE TOOL AND DIA.	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	REMARKS (WATER LEVELS, WATER RETURN, DRILLING FLUID, CASING DEPTH)	ELEVATION	DEPTH FT	GRAPHIC LOG	BOX/SAMPLE NO.	MATERIAL CLASSIFICATION / PHYSICAL DESCRIPTION
HSA 7 3/4"						0			TAILINGS
						2			CLAYEY SILT TO SANDY SILT WITH LITTLE GRAVEL, LIGHT BROWN TO TAN, MOIST
				HARD DRILLING IN GRAVEL & ROCK		4			ROCK, GRAY, HARD
	35 40 32	18"	14"	SAMPLE		6	SPT		
						8			LAYERS OF SILTY GRAVEL AND GRAVELLY SILT, TAN, DRY. GRAVEL LAYERS ARE VERY DENSE.
	50/3"	3"	0			10	SPT		
						12			
				SMOOTH DRILLING		14			
	45 50/3"	9"	9"	SAMPLE		16	SPT		SILTSTONE WITH TRACE OF FINE GRAVEL, TAN, NEARLY DRY
						18			
	50/5"	5"	5"	SAMPLE		20	SPT		
						22			
						24			
	50/2"	2"	1"	WASTED		26	SPT		SILTSTONE, GRAY, HARD, DRY
						28			

HOLE NO. HA-1

INTERNATIONAL ENGINEERING CO., INC.

SHEET 2 OF 2

DRILL LOG	PROJECT CHEVRON PHOSPHATE	JOB NO. 2151	HOLE NO. HA-1

TYPE TOOL AND DIA.	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	REMARKS (WATER LEVELS, WATER RETURN, DRILLING FLUID, CASING DEPTH)	ELEVATION	DEPTH FT	GRAPHIC LOG	BOX/SAMPLE NO.	MATERIAL CLASSIFICATION PHYSICAL DESCRIPTION
HSA 7¾"				HARDER DRILLING FROM 28'					
	50/2"	2"	2"	SAMPLE		30	SPT		
	50/2"	2"	0"			35	SPT		SILTSTONE, GRAY, HARD, DRY
	50/1"	1"	1"	WASTED		40	SPT		
	50/1			SAMPLE		45	SPT		BOTTOM OF HOLE 45.1

Depth scale: 30, 32, 34, 36, 38, 40, 42, 44, 46, 48, 50, 52, 54, 56, 58, 60

HOLE NO. HA-1

INTERNATIONAL ENGINEERING CO., INC.

DRILL LOG	PROJECT CHEVRON PHOSPHATE		JOB NO. 2151	HOLE NO. HA-2
SITE TAILINGS DAM EXPANSION	BEGUN 2.30 P 4-9-85	COMPLETED 11.30 A 4-10-85	HOLE SIZE 7 3/4	ANGLE FROM HORIZ. & BEARING VERT.
COORDINATES 32141.6 N - 59959.6	DEPTH/EL. GROUND WATER 28.2'		GROUND EL. 5921.5	DEPTH/EL. TOP OF ROCK 12.5
DRILLING CONTRACTOR ERICKSON - FORD	CORE RECOV. LENGTH/% 5.0' - 100%	SAMPLES 6	CORE BOXES ONE	DEPTH/EL. BOTTOM OF HOLE 45.1
DRILL MAKE AND MODEL CME 55	LOGGED BY: A.S. CHRISTENSEN			

TYPE TOOL AND DIA.	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	REMARKS WATER LEVELS WATER RETURN DRILLING FLUID CASING DEPTH	ELEVATION	DEPTH FT	GRAPHIC LOG	BOX/SAMPLE NO	MATERIAL CLASSIFICATION PHYSICAL DESCRIPTION
HSA 7 3/4"						0–1			ROAD FILL, SILT SAND & GRAVEL
						1–4.5			SANDY SILT, TAN, WITH TRACE OF FINE GRAVEL, SLIGHTLY WET.
	3 4 5	18"	18"	SAMPLE		5–6.5	SPT		
						4.5–11.8			SILT WITH SOME GYPSUM AND TRACE OF FINE SAND, BROWN TO GRAY BROWN, SLIGHTLY WET.
	PUSH	24"	17"			10–12	SHELBY		
	10 30 23	18"	16"	SAMPLE OF SILTSTONE		12–13.5	SPT		
	50/5	5"	5"	SAMPLE		15	SPT		
	28 46 50/5	17"	17"	SAMPLE		20–21.5	SPT		SILTSTONE WITH TRACE OF GRAVEL AND GYPSUM, MOIST TO NEARLY DRY, GRAY.
				SMOOTH, MED. HARD DRILLING WITH AUGER		21.5–24			
	50/5"	5"	5"	WASTED		25	SPT		
						28			

HOLE NO. HA-2

INTERNATIONAL ENGINEERING CO., INC. SHEET 2 OF 2

DRILL LOG	PROJECT CHEVRON PHOSPHATE	JOB NO. 2151	HOLE NO. HA-2

SAMPLE DATA: TYPE TOOL AND DIA.	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	REMARKS: WATER LEVELS, WATER RETURN, DRILLING FLUID, CASING DEPTH	ELEVATION	DEPTH FT	GRAPHIC LOG	BOX/SAMPLE NO.	MATERIAL CLASSIFICATION: PHYSICAL DESCRIPTION
HSA 7¾"				W.L. 4/10 28.2' ▼					
	50/5	5"	5"	SAMPLE HARD DRILLING WITH AUGER		30	SPT		SILTSTONE, GRAY, MOIST TO DRY.
						32			
				4-9-85 4-10-85		34			
	50/2	2"	0			36	SPT		
						38			
NW CORE 2" DIA.	50/1	1"	2"	SAMPLE		40	SPT		SILTSTONE, VERY FRACTURED AND CRUMBLING WITH MANY GYPSUM LENSES TO 1/4" MAX.
	RUN #1	5.0'	5.0'	RQD: 30%		42 44			
						46			BOTTOM OF HOLE 45.1
						48 50 52 54 56 58 60			

HOLE NO. HA-2

INTERNATIONAL ENGINEERING CO., INC. SHEET 1 OF 2

DRILL LOG

PROJECT: CHEVRON PHOSPHATE		JOB NO.: 2151	HOLE NO.: HA-3
SITE: TAILINGS DAM EXPANSION	BEGUN: 12.45 PM 4-10-85	COMPLETED: 3.15 PM 4-10-85	HOLE SIZE: 7 3/4"
ANGLE FROM HORIZ. & BEARING: VERT.			
COORDINATES: 31821.0 N - 60650.9 E	DEPTH/EL. GROUND WATER: 22' ±	GROUND EL.: 5799.6	DEPTH/EL. TOP OF ROCK: 9.5'
DRILLING CONTRACTOR: ERICKSON - FORD	CORE RECOV. LENGTH/%: N/A	SAMPLES: 3	CORE BOXES: N/A
DEPTH/EL. BOTTOM OF HOLE: 30.1			
DRILL MAKE AND MODEL: CME 55	LOGGED BY: A.S. CHRISTENSEN		

TYPE TOOL AND DIA.	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	REMARKS (WATER LEVELS, WATER RETURN, DRILLING FLUID, CASING DEPTH)	ELEVATION	DEPTH FT	GRAPHIC LOG	BOX/SAMPLE NO.
HSA, 7 3/4"						0–5		
	PUSH	24"	24"			5–7	SHELBY	
	7 17 45	18"	18"	SAMPLE		7–8.5	SPT	
	50/3	3"	0	SMOOTH BUT QUITE HARD DRILLING		10	SPT	
	50/3	3"	0			15	SPT	
	50/3"	3"	3"	SAMPLE W.L. 22' ± ▼		20	SPT	
	50/2½	2½	2"	SAMPLE		25	SPT	

MATERIAL CLASSIFICATION — PHYSICAL DESCRIPTION

SILT WITH MUCH ORGANIC MATERIAL IN TOP 9 INCHES, GRAY, MOIST TO WET

GRADING TO

CLAYEY SILT WITH GYPSUM AND GYPSUM LENSES TO 1/4" MAX, GRAY, SLIGHTLY WET TO MOIST.

SILTSTONE, GRAY, HARD NEARLY DRY

CHANGING TO

GRAY TO GRAY BROWN, WET.

HOLE NO. HA-3

INTERNATIONAL ENGINEERING CO., INC.

SHEET 2 OF 2

DRILL LOG	PROJECT CHEVRON PHOSPHATE	JOB NO. 2151	HOLE NO. HA-3

TYPE TOOL AND DIA.	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	REMARKS WATER LEVELS WATER RETURN DRILLING FLUID CASING DEPTH	ELEVATION	DEPTH FT	GRAPHIC LOG	BOX/SAMPLE NO.	MATERIAL CLASSIFICATION PHYSICAL DESCRIPTION
HSA 7¾									SILTSTONE WITH HARD GRAVEL SIZE FRAGMENTS, GRAY, WET.
	50/1"	1"	1"			30	SPT		BOTTOM OF HOLE 30.1
						32			
						34			
						36			
						38			
						40			
						42			
						44			
						46			
						48			
						50			
						52			
						54			
						56			
						58			
						60			

HOLE NO. HA-3

INTERNATIONAL ENGINEERING CO., INC.

DRILL LOG	PROJECT CHEVRON PHOSPHATE			JOB NO. 2151	HOLE NO. HA-4
SITE TAILINGS DAM EXPANSION	BEGUN 4.0 PM 4-10-85	COMPLETED 9.0 AM 4-11-85	HOLE SIZE 7¾	ANGLE FROM HORIZ. & BEARING VERT.	
COORDINATES 31414.1 N - 61373.7 E	DEPTH/EL. GROUND WATER NO WATER		GROUND EL. 5891.9	DEPTH/~~EL~~. TOP OF ROCK 5 ±	
DRILLING CONTRACTOR ERICKSON - FORD	CORE RECOV. LENGTH/% 5.0' 100%	SAMPLES ONE	CORE BOXES ONE	DEPTH/EL. BOTTOM OF HOLE 24.5'	
DRILL MAKE AND MODEL CME 55	LOGGED BY: A.S. CHRISTENSEN				

TYPE TOOL AND DIA.	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	REMARKS WATER LEVELS WATER RETURN DRILLING FLUID CASING DEPTH	ELEVATION	DEPTH FT	GRAPHIC LOG	BOX/SAMPLE NO	MATERIAL CLASSIFICATION PHYSICAL DESCRIPTION
HSA 7¾"						0–1			ROAD FILL, SAND & GRAVEL
						1–5			SILT, LOOSE, MOIST & GRAY
	20 21 25	18"	18"	SAMPLE		6	SPT		SILTSTONE WITH SOME GYPSUM LENSES, VERY WEATHERED AND FRACTURED, GRAY
	50/5	5"	1"	NO SAMPLE SMOOT BUT QUITE HARD DRILLING		10	SPT		GRADING TO
	50/2	2"	0	VERY HARD DRILLING		15	SPT		SILTSTONE, HARD, BROWN AND NEARLY DRY.
				4-10-85 / 4-11-85		19			
NW CORE 2"DIA	RUN #1	5'	5'	RQD = 38%		19–24			SILTSTONE WITH MANY GYPSUM LENSES, VERY FRACTURED. GRAY & REDDISH BROWN LAYERED, SOFT TO MED HARD WITH SOFT ZONES AT 21.5 & 23.5
						24.5			BOTTOM OF HOLE 24.5'

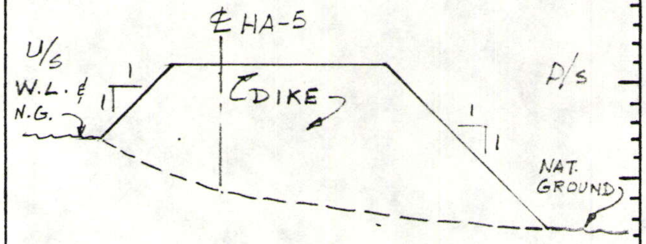
Depth scale: 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28

HOLE NO. HA-4

INTERNATIONAL ENGINEERING CO., INC. SHEET 1 OF 2

DRILL LOG

PROJECT: CHEVRON PHOSPHATE			JOB NO.: 2151	HOLE NO.: HA-5
SITE: MIDDLE OF RETENTION POND DIKE	BEGUN: 11:25 A 4-14-85	COMPLETED: 4:30 PM 4-14-85	HOLE SIZE: 7¾"	ANGLE FROM HORIZ. & BEARING: VERT.
COORDINATES: (SCALED) 30069.0 62179.5	DEPTH/EL. GROUND WATER: NOT DETERMINED		GROUND EL.: 5731.5	DEPTH/EL. TOP OF ROCK: 50'
DRILLING CONTRACTOR: ERICKSON - FORD	CORE RECOV. LENGTH/%: N/A	SAMPLES: 7	CORE BOXES: NO CORE	DEPTH/EL. BOTTOM OF HOLE: 50.0'
DRILL MAKE AND MODEL: CME 55	LOGGED BY: A.S. CHRISTENSEN			

SAMPLE DATA: TYPE TOOL AND DIA.	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	REMARKS: WATER LEVELS, WATER RETURN, DRILLING FLUID, CASING DEPTH	ELEVATION	DEPTH FT	GRAPHIC LOG	BOX/SAMPLE NO.	MATERIAL CLASSIFICATION: PHYSICAL DESCRIPTION
HSA 7¾"						0–4			
				EASY AUGERING		4–6			
						8			DIKE FILL: SILTY GRAVEL AND ROCKFILL
	PUSH	24"	6"	CUTTING EDGE OF TUBE BADLY BENT, SAMPLE WASTED		10–12	SHELBY		SILT & GRAVEL, GRAY SATURATED
						12–14			GRADING TO
	PUSH	18"	18"	REFUSAL AT 18"		15–16.5	SHELBY		SILT, REDDISH BROWN, WITH
	3 3 4	18"	12"	SAMPLE WASTED		16.5–18	SPT		SOME ORGANIC MATERIAL, VERY WET.
1/18"	PUSH	24"	0	NO RECOVERY FROM SHELBY. SPT TAKEN IN SAME AREA, DISCOUNT BLOWCOUNT		20–22	SHELBY	SPT	SILT WITH TRACE OF ORGANIC MAT'L, SATURATED
	PUSH	24"	20"			22–24	SHELBY		
	2 2 5	18"	18"	SAMPLE WASTED		24–25.5	SPT		SILT WITH LITTLE COARSE SAND, REDDISH BROWN
						26–28			

HOLE NO. HA-5

INTERNATIONAL ENGINEERING CO., INC.

DRILL LOG

PROJECT	JOB NO.	HOLE NO.
CHEVRON PHOSPHATE	2151	HA-5

SAMPLE DATA: TYPE TOOL AND DIA.	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	REMARKS: WATER LEVELS, WATER RETURN, DRILLING FLUID, CASING DEPTH	ELEVATION	DEPTH FT	GRAPHIC LOG	BOX/SAMPLE NO.	MATERIAL CLASSIFICATION: PHYSICAL DESCRIPTION
HSA 7¾"									MATERIAL BECAME HARDER AT 28' DEPTH
				EASY AUGERING		30			
	PUSH	24"	27"				SHELBY		SILT WITH COARSE GRAVEL AT BOTTOM OF TUBE.
						32			
						34			
	PUSH	24	0	NO RECOVERY		36	SHELBY		
	PUSH	24"	24"			38	SHELBY		
	B 12 15	18"	18"	SAMPLE		40	SPT		SANDY GRAVELLY SILT, BROWN WITH FEW GRAY LAYERS, VERY WET TO SATURATED.
				HARD AUGERING TO 43'		42			
						44			
	PUSH	19"	22"			46	SHELBY		SANDY SILT, REDDISH BROWN
				EASIER AUGERING TO 48'		48			
				HARD AUGERING. REFUSAL AT 49.7'					WEATHERED SILTSTONE WITH GYPSUM LENSES, HARD, BROWN.
	50/4½	4½	4½	SAMPLE		50	SPT		BOTTOM OF HOLE 50.0
						52			
						54			
						56			
						58			
						60			

HOLE NO. HA-5

INTERNATIONAL ENGINEERING CO., INC. SHEET 1 OF 1

DRILL LOG	PROJECT CHEVRON PHOSPHATE		JOB NO. 2151	HOLE NO. HA-6
SITE TAILINGS DAM EXPANSION	BEGUN 9.35 AM 4-11-85	COMPLETED 11.20 AM 4-11-85	HOLE SIZE 7 3/4	ANGLE FROM HORIZ. & BEARING VERT.
COORDINATES 30096.1 N - 61945.8 E	DEPTH/EL. GROUND WATER No WATER		GROUND EL. 5758.9	DEPTH/~~EL.~~ TOP OF ROCK 0'
DRILLING CONTRACTOR ERICKSON - FORD	CORE RECOV. LENGTH/% 4'-6" 90%	SAMPLES 2	CORE BOXES ONE	DEPTH/EL. BOTTOM OF HOLE 20.1
DRILL MAKE AND MODEL CME 55	LOGGED BY: A.S. CHRISTENSEN			

SAMPLE DATA: TYPE TOOL AND DIA.	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	REMARKS: WATER LEVELS, WATER RETURN, DRILLING FLUID, CASING DEPTH	ELEVATION	DEPTH FT	GRAPHIC LOG	BOX/SAMPLE NO	MATERIAL CLASSIFICATION PHYSICAL DESCRIPTION
HSA 7 3/4"				SMOOTH BUT QUITE HARD AUGERING		2			SILTSTONE, GRAY AND REDDISH BROWN, LAYERED, OCCASIONAL WITH FEW PIECES OF GRAVEL AND TRACE OF GYPSUM, NEARLY DRY
						4			
	50/1"	1"	2"	SAMPLE GRAY SILTSTONE		6	SPT		
						8			
	50/4"	4"	4"	SAMPLE REDDISH BROWN		10	SPT		
						12			
						14			
NW CORE 2" DIA.	50/1½	1½	½	NO SAMPLE		16	SPT		SILTSTONE WITH MANY HAIRLINE GYPSUM SEAMS, VERY FRACTURED. HARDNESS OF CORE VARY. SOFT ZONE 17.5' TO 17.8'
	RUN #1	5.0'	4'-6"	RQD: 45%		18			
						20			BOTTOM OF HOLE 20.1
						22			
						24			
						26			
						28			

HOLE NO. HA-6

DRILL LOG

PROJECT	JOB NO.	HOLE NO.
CHEVRON PHOSPHATE	2151	HA-7

SITE	BEGUN	COMPLETED	HOLE SIZE	ANGLE FROM HORIZ. & BEARING
BORROW AREA	12.45 PM 4-11-85	11.50 A 4-12-85	2"	VERT.

COORDINATES	DEPTH/EL. GROUND WATER	GROUND EL.	DEPTH/EL. TOP OF ROCK
29458.7 N - 60352.5 E	35' ±	5901.8	4.0'

DRILLING CONTRACTOR	CORE RECOV. LENGTH/%	SAMPLES	CORE BOXES	DEPTH/EL. BOTTOM OF HOLE
ERICKSON - FORD	64' 100%	N/A	5	73.5'

DRILL MAKE AND MODEL	LOGGED BY:
CME 55	A.S. CHRISTENSEN

SAMPLE DATA: TYPE TOOL AND DIA.	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	REMARKS: WATER LEVELS, WATER RETURN, DRILLING FLUID, CASING DEPTH	ELEVATION	DEPTH FT	GRAPHIC LOG	BOX/SAMPLE NO.	MATERIAL CLASSIFICATION: PHYSICAL DESCRIPTION
HSA, 7 3/4"						0–4			SILT, REDDISH BROWN, MOIST
				BULK SAMPLE OF AUGER CUTTINGS 0'–10'		4–10			SILTSTONE, WEATHERED, MOIST GRADING TO FRACTURED, MED HARD
NW CORE 2" DIA	RUN #1	4.0'	4.0'	RQD: 37%		10–12.3		BOX #1	
						12.3–13			SILTSTONE WITH SOME GYPSUM, HARD, LIGHT BROWN & GRAY MOTTLED
						13–13.5			GYPSUM WITH SOME SILTSTONE, WHITE MED. HARD.
	RUN #2	5.0'	5.0'	GOOD WATER RETURN; RQD: 20%		13.5–15.5			SILTSTONE WITH SEVERAL GYPSUM LENSES TO 1/4", VERY FRACTURED, MED. HARD, BROWN.
						15.5–19			MIXTURE OF SILTSTONE AND SAND-STONE WITH SOME GYPSUM, MOTTLED AND LAYERED, VERY IRREGULAR, REDDISH BROWN TO WHITE MED. HARD. VERT. AND HOR. FRACTURES.
	RUN #3	5.0'	5.0'	RQD: 75%		19–24			SILTSTONE WITH MANY GYPSUM LENSES FROM HAIRLINE TO 1/8" MAX. MED HARD FROM BROWN TO GRAY BROWN, LAYERED. VERY FRACT 19.5-20.3 AND 23.0-27.6
	RUN #4	5.0'	5.0'	RQD: 32%		24–28		BOX #2	SANDSTONE, SILTSTONE AND GYPSUM. LT. BROWN TO GRAY MARBLED, HARD. VERY IRREGULAR COLORING

HOLE NO. HA-7

INTERNATIONAL ENGINEERING CO., INC.

DRILL LOG	PROJECT: CHEVRON PHOSPHATE	JOB NO. 2151	HOLE NO. HA-7

Type Tool and Dia.	Method N- Blow Count	Advance	Recovery	Remarks (Water Levels, Water Return, Drilling Fluid, Casing Depth)	Elevation	Depth FT	Graphic Log	Box/Sample No.	Material Classification – Physical Description
NW CORE 2" DIA									SEE SHEET 1
	RUN #5	5.0'	5.0'	GOOD WATER RETURN RQD: 50%		30–32		BOX #2	SANDSTONE AND SILTSTONE, BROWN TO GRAYISH LAYERED VERY FRACTURED TO FRACT. WITH MANY GYPSUM LENSES FROM HAIRLINE TO 3/16" MAX. MED HARD TO HARD WITH A 1" SOFT ZONE AT 32.3'. 1/2" GYPSUM LENSE @ 42.5'
	RUN #6	5.0'	5.0'	W.L. 4/12-85 RQD: 65%		34–38			
	RUN #7	5.0'	5.0'	RQD: 50%		40–42		BOX #3	
	RUN #8	5.0'	5.0'	RQD: 33%		44–48			SANDSTONE & SILTSTONE, FRACT. W/ MANY THIN GYPSUM LENSES TO 1/4" MAX., BROWN SILTSTONE, VERY FRACT. & SOFT WITH SEVERAL GYPSUM LENSES TO 1/8" MAX REDDISH BROWN. CRUMBLING ZONE 47.2 TO 48.2'
	RUN #9	5.0'	5.0'	RQD: 38%		50–52			SILTSTONE & SOME SANDSTONE WITH SEVERAL GYPSUM LENSES TO 3/8" MAX, VERY FRACT. TO FRACT. COLOR FROM BROWN TO GRAYISH.
	RUN #10	5.0'	5.0'	RQD: 75% GOOD WATER RETURN		54–60		BOX #4	SILTSTONE, FRACT., WITH MANY GYPSUM LENSES TO 1/8" MAX., MED. HARD TO HARD, BROWNISH

HOLE NO. HA-7

INTERNATIONAL ENGINEERING CO., INC.

DRILL LOG	PROJECT CHEVRON PHOSPHATE	JOB NO. 2151	HOLE NO. HA-7

TYPE TOOL AND DIA.	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	REMARKS WATER LEVELS WATER RETURN DRILLING FLUID CASING DEPTH	ELEVATION	DEPTH FT	GRAPHIC LOG	BOX/SAMPLE NO.	MATERIAL CLASSIFICATION PHYSICAL DESCRIPTION
NW CORE	RUN #11	5.0	5.0	RQD: 80%		62		BOX #4	
	RUN #12	5.0'	5.0'	GOOD WATER RETURN RQD: 83%		64 66 68		BOX #5	SILTSTONE, FRACTURED, WITH SEVERAL GYPSUM LENSES TO 1/8", A 3/8" GYPSUM LENSE IN SOFT SILTST. 59.3'. ONE 3/8" LENSE AT 64.3, ONE 1/4" LENSE AT 72.7. SOFT SEAM AT 59.7 SOFT AREA 64.0'-64.7' REDDISH BROWN TO BROWN, MED. HARD TO HARD
	RUN #13	5.0'	5.0'	RQD: 93%		70 72			
						74 76 78 80			BOTTOM OF HOLE 73.5

HOLE NO. HA-7

INTERNATIONAL ENGINEERING CO., INC.

DRILL LOG	PROJECT CHEVRON PHOSPHATE		JOB NO. 2151	HOLE NO. HA-8
SITE BORROW AREA	BEGUN 12.30 PM 4-12-85	COMPLETED 9.45 AM 4-14-85	HOLE SIZE 2"	ANGLE FROM HORIZ. & BEARING VERT.
COORDINATES 29259.3N - 59422.2	DEPTH/EL. GROUND WATER 27'		GROUND EL. 5929.6	DEPTH/EL. TOP OF ROCK 3.0'
DRILLING CONTRACTOR ERICKSON - FORD	CORE RECOV. LENGTH/%	SAMPLES	CORE BOXES	DEPTH/EL. BOTTOM OF HOLE
DRILL MAKE AND MODEL CME 55	LOGGED BY: A.S. CHRISTENSEN			

SAMPLE DATA: TYPE TOOL AND DIA.	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	REMARKS: WATER LEVELS, WATER RETURN, DRILLING FLUID, CASING DEPTH	ELEVATION	DEPTH FT	GRAPHIC LOG	BOX/SAMPLE NO.	MATERIAL CLASSIFICATION — PHYSICAL DESCRIPTION
HSA 7¾"				EASY DRILLING		0–3			SILT, LOOSE, MOIST REDDISH BROWN
						3–10			SILTSTONE, WEATHERED REDDISH BROWN, SOFT
NW CORE 2" DIA	RUN #1	4.0	4.0	GOOD WATER RETURN RQD: 27%		10–14		BOX #1	SILTSTONE WITH FEW GYPSUM LENSES TO 1/16", ONE 1/4" LENSE AT 10.3', VERY FRACT., SOFT TO MED. HARD, REDDISH BROWN.
	RUN #2	5.0	5.0	RQD: 62%		14–19		BOX #1	SILTSTONE WITH MANY GYPSUM LENSES TO 1/8" - ONE 3/8" LENSE AT 21.0'. SOFT & CRUMBLING 21.0-21.2 AND 22.7'-23.5. MED HARD & FRACTURED TO VERY FRACT.
	RUN #3	5.0	5.0	GOOD WATER RETURN RQD: 52%		19–24		BOX #1	SILTSTONE AND SANDSTONE WITH MANY GYPSUM LENSES AND POCKETS. BROWN TO LIGHT GRAY, HARD.
	RUN #4	4.9	4.0	LOST CIRCULATION 26'-27' RQD: 59	4-14-85 WL ▼	24–28		BOX #2	SILTSTONE AND GYPSUM, VERY LAMINATED, GRAY AND BROWN, HARD. SILTSTONE WITH MANY GYPSUM LAYERS AND LENSES TO 1/2" MAX. SOFT & CRUMBLING, BROWN.

HOLE NO. HA-8

INTERNATIONAL ENGINEERING CO., INC. SHEET 2 OF 4

DRILL LOG

PROJECT: CHEVRON PHOSPHATE | JOB NO. 2151 | HOLE NO. HA-8

SAMPLE DATA: TYPE TOOL AND DIA.	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	REMARKS: WATER LEVELS, WATER RETURN, DRILLING FLUID, CASING DEPTH	ELEVATION	DEPTH FT	GRAPHIC LOG	BOX/SAMPLE NO.	MATERIAL CLASSIFICATION: PHYSICAL DESCRIPTION
NW CORE									CORE LOSS BETW 27.2 & 28.8
	RUN #5	5.0'	5.0'	FAIR TO POOR WATER RETURN RQD: 70% NO WATER RETURN		30, 32, 34		BOX #2	SILTSTONE WITH GYPSUM LAYERS AND POCKETS, SLIGHTLY FRACT., LT. GRAY TO BROWN, COLORS INTERMIXED. HARD.
	RUN #6	5.0'	5.0'	RQD: 85%		36, 38			SILTSTONE WITH MANY GYPSUM LENSES TO 3/8" MAX, GRAY BROWN TO BROWN, HARD
	RUN #7	5.0'	4.9'	RQD: 92%		40, 42		BOX #3	SILTSTONE WITH LITTLE GYPSUM, LT. GRAY TO BROWN, MARBLED AND LAMINATED, HARD
	RUN #8	5.0'	5.0'	RQD: 92%		44, 46, 48			SILTSTONE WITH MANY GYPSUM LENSES TO 1/8" MAX, GRAY & BR LAYERED AND MARBLED. FRACT. WITH 2 SOFT JOINTS. GYPSUM & SILTSTONE MIXED, GRAY-BR.
	RUN #9	4.1	4.1	RQD: 94%		50, 52		BOX #4	SILTSTONE WITH MANY GYPSUM LENSES FROM HAIRLINE TO 1/8" AND OCCASIONAL 1/2" LENSE FRACT., HARD, GRAY BROWN TO BROWN.
	RUN #10	5.2'	5.2'	RQD: 81% NO WATER RETURN		54, 56, 58, 60		BOX #5	

HOLE NO. HA-8

INTERNATIONAL ENGINEERING CO., INC.

DRILL LOG	PROJECT: CHEVRON PHOSPHATE	JOB NO. 2151	HOLE NO. HA-8

TYPE TOOL AND DIA.	METHOD N- BLOW COUNT	ADVANCE	RECOVERY	REMARKS (WATER LEVELS, WATER RETURN, DRILLING FLUID, CASING DEPTH)	ELEVATION	DEPTH FT	GRAPHIC LOG	BOX/SAMPLE NO.	MATERIAL CLASSIFICATION PHYSICAL DESCRIPTION
NW CORE	RUN 11	5.2'	5.2'	NO WATER RETURN RQD: 87%		62			SILTSTONE WITH MANY GYPSUM LENSES FROM HAIR-LINE TO 1/8", ONE 1/2" LENSE AT 64.0', ONE 3/4" LENSE AT 65.0'., FRACT., HARD. GRAY BROWN TO BROWN.
	RUN 12	5.3'	5.2	RQD: 86%		64, 66, 68			
	RUN 13	5.2'	5.2'	RQD: 68%		70, 72, 74			SILTSTONE WITH MANY GYPSUM LENSES FROM HAIRLINE TO 1/8" WITH OCCASIONAL 1/4" LENSE. FRACT., MED HARD TO HARD WITH SEVERAL SOFT JOINTS 72.7 TO 74.0 GRAY BROWN TO DARK BROWN.
	RUN 14	5.0	5.0	RQD: 87%		76, 78			
	RUN 15	5.0'	5.0	RQD: 80%		80, 82, 84			
	RUN 16	5.0	5.0	RQD: 92% NO WATER RETURN		86, 88			SILTSTONE WITH SOME HAIRLINE GYPSUM LENSES, SEVERAL VERT. & HOR. LENSES 1/16" TO 3/16" SLIGHTLY FRACT., HARD. GRAY BROWN TO DARK BROWN
	RUN 17	5.0'	5.0'	RQD: 88%		90, 92			

DRILL LOG	PROJECT CHEVRON PHOSPHATE	JOB NO. 2151	HOLE NO. HA-8

TYPE TOOL AND DIA.	METHOD N- BLOW COUNT	ADVANCE	RECOVERY	REMARKS: WATER LEVELS, WATER RETURN, DRILLING FLUID, CASING DEPTH	ELEVATION	DEPTH FT	GRAPHIC LOG	BOX/SAMPLE NO.	MATERIAL CLASSIFICATION PHYSICAL DESCRIPTION
NW CORE						94		BOX 8	SEE SHEET 3
	RUN 18	5.0'	5.0'	NO WATER RETURN RQD: 82%		96 98		BOX 9	SILTSTONE WITH VERT & HOR. GYPSUM LENSES FROM HAIRLINE TO 3/8" MAX. SLIGHTLY FRACTURED, HARD, GRAY BROWN TO DARK BROWN.
	RUN 19	5.0'	5.0'	RQD: 95%		100 102			
						104			BOTTOM OF HOLE 104.0'
						106 108 110			

APPENDIX B
LABORATORY TEST RESULTS

Laboratory Testing

CHEVRON PHOSPHATE FACILITIES

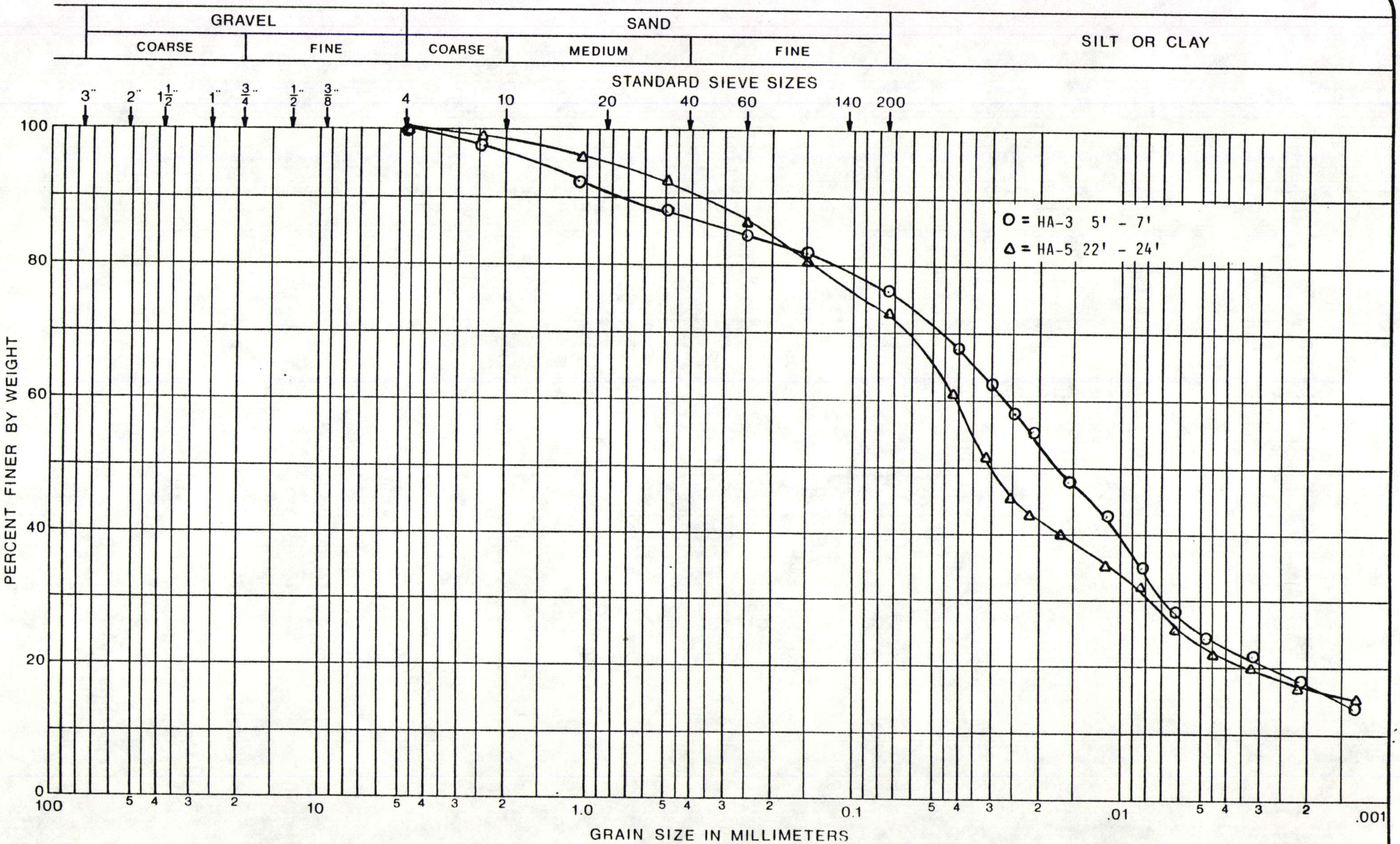
May 1985

ROLLINS, BROWN AND GUNNELL, INC.
PROFESSIONAL ENGINEERS
1435 West 820 North ■ P.O. Box 711 ■ Provo, Utah 84603
Telephone (801) 374-5771

Table No 6 **SUMMARY OF TEST DATA**

Project Chevron Phosphate Facilities Feature ______ Location Vernal, Utah

HOLE NO.	DEPTH BELOW GROUND SURFACE	STANDARD PENETRATION BLOWS PER FOOT	IN-PLACE			UNCONFINED COMPRESSIVE STRENGTH (lb/ft²)	FRICTION ANGLE φ	CONSISTENCY LIMITS			MECHANICAL ANALYSIS			UNIFIED SOIL CLASSIFICATION SYSTEM
			Unit Weight (lb/ft³)	Moisture (%)	Permeabil. ft/yr			L.L (%)	P.L. (%)	P.I. (%)	% Gravel	% Sand	% Silt & Clay	
HA-2	10-12'	SH	115.0	12.3										
HA-3	5-7'	SH	94.9	27.9		328		24.5	22.8	1.7	0.0	23.3	76.7	ML
HA-5	15-16.5'	SH	110.0	19.3							0.1	16.8	83.1	ML
HA-5	22-24'	SH	114.5	20.2				21.0	16.5	4.5	0.0	26.5	73.5	CL-ML
HA-5	30-32'	SH	112.0	23.3	4.5	233					0.1	47.0	52.9	ML
HA-5	37-39'	SH	115.1	21.0		180		23.1	21.4	1.7	25.8	38.3	35.9	ML
HA-5	45-46'	SH	115.1	19.3										



ROLLINS, BROWN AND GUNNELL, INC.
PROFESSIONAL ENGINEERS

GRAIN SIZE DISTRIBUTION CURVE

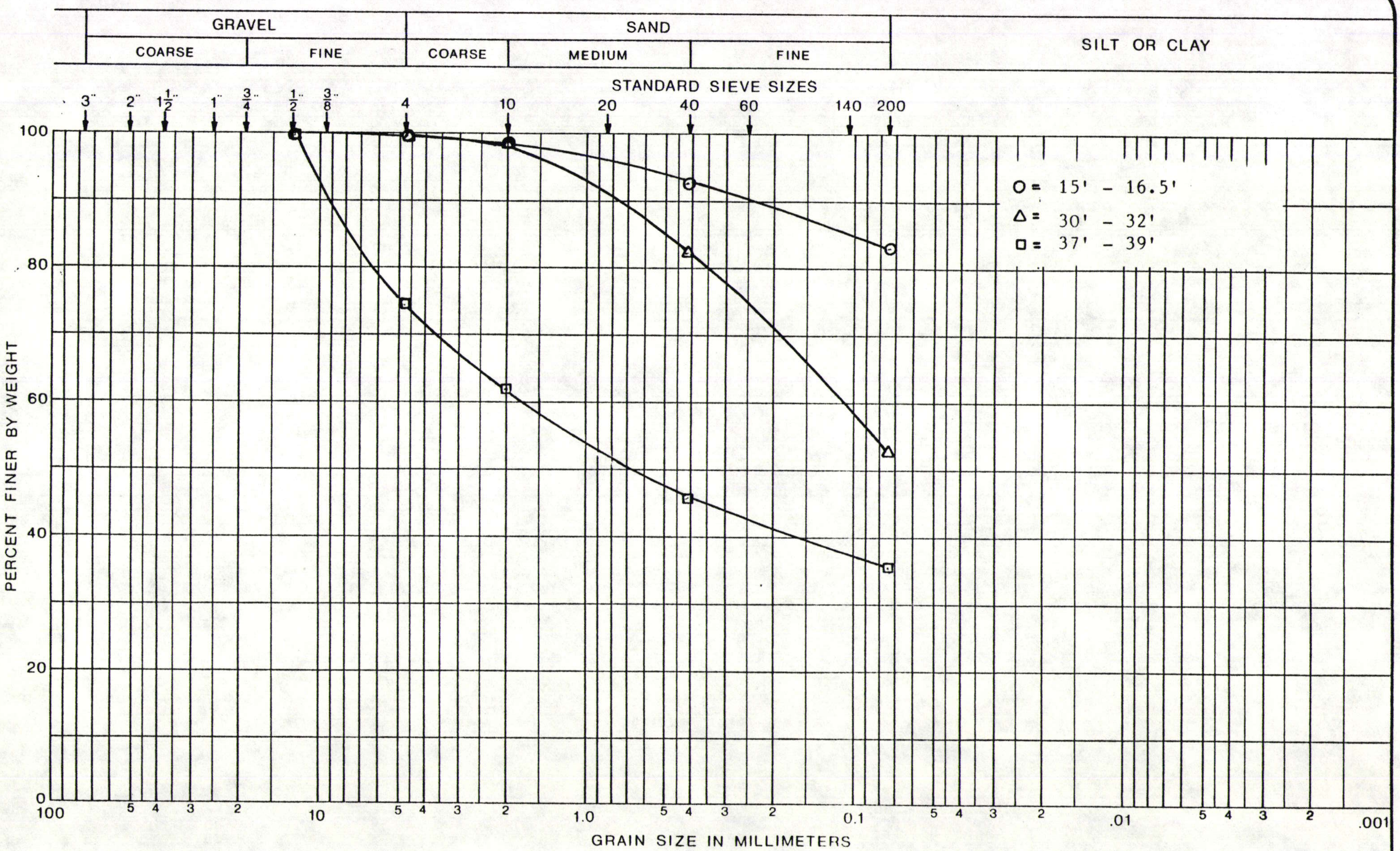
Project: CHEVRON PHOSPHATE FACILITIES

Location: Vernal, Utah

HOLE NO. HA-3

DEPTH: HA-5

FIGURE NO.



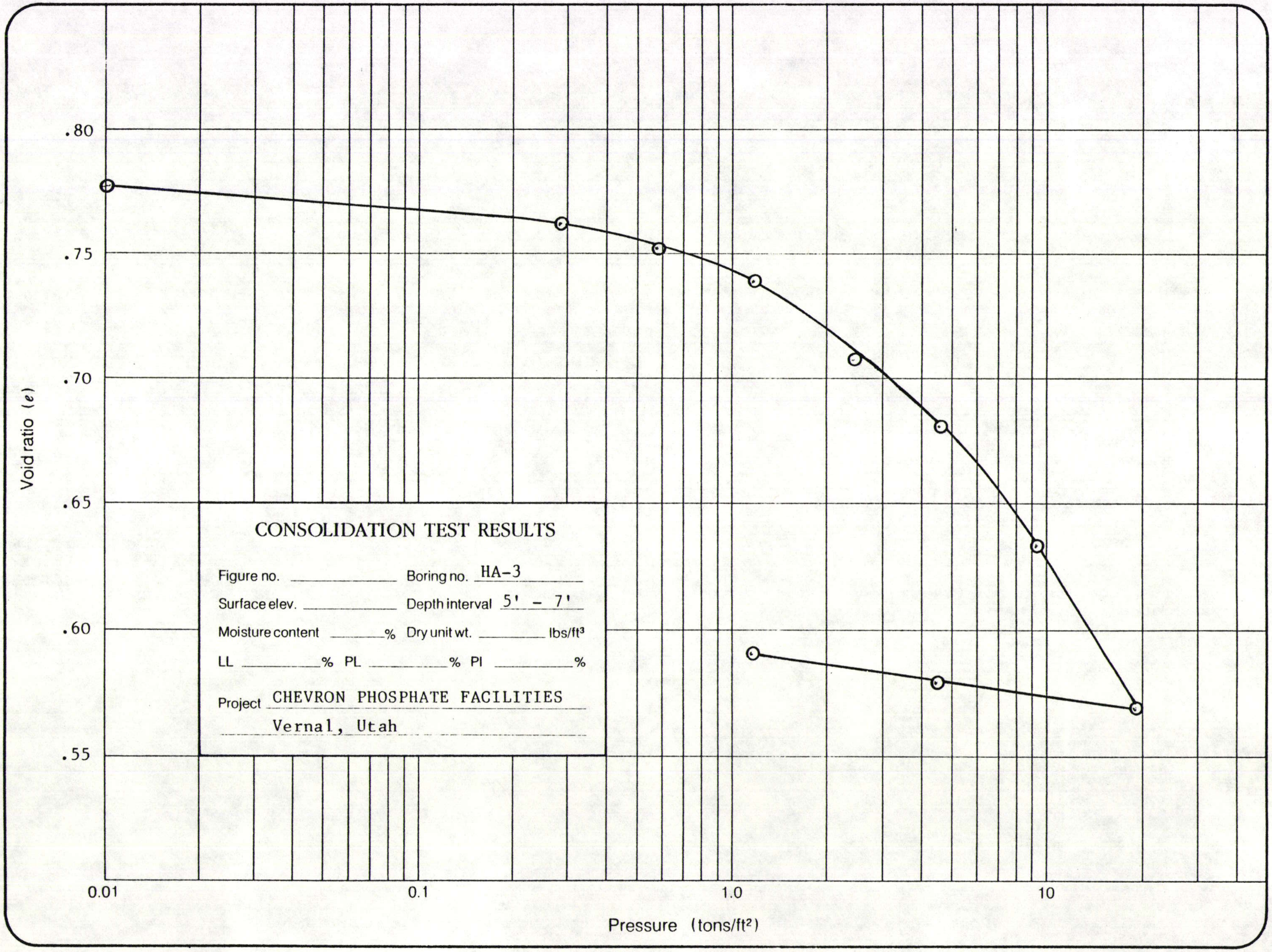
ROLLINS, BROWN AND GUNNELL, INC.
PROFESSIONAL ENGINEERS

GRAIN SIZE DISTRIBUTION CURVE

Project: CHEVRON PHOSPHATE FACILITIES
Location: Vernal, Utah

HOLE NO. HA-5
DEPTH:

FIGURE NO.



CONSOLIDATION TEST RESULTS

Figure no. ______ Boring no. HA-3

Surface elev. ______ Depth interval 5' - 7'

Moisture content ______% Dry unit wt. ______ lbs/ft³

LL ______% PL ______% PI ______%

Project CHEVRON PHOSPHATE FACILITIES

Vernal, Utah

Table No. 1
Time Consolidation Tests
Sample HA-3, 5-7 feet

Elapsed Time, min	Dial Reading 0.58 tsf	Dial Reading 1.15 tsf	Dial Reading 2.30 tsf
0	.0395	.0457	.0528
.1	.0399	.0470	.0546
0.25	.0410	.0471	.0547
0.5	.0411	.0472	.0549
1	.0412	.0473	.0551
2	.0413	.0475	.0553
4	.0414	.0476	.0555
8	.0416	.0478	.0558
15	.0420	.0481	.0563
30	.0423	.0484	.0567
60	.0426	.0488	.0573
120	(180).0433	.0492	.0582
240		.0499	.0591
480	(434).0441	.0508	.0610
1420	(1414).0457	.0528	(1425).0699

Time Consolidation Test Cont.
Sample HA-3, 5-7 feet

Elapsed Time, min	Dial Reading 4.60 tsf	Dial Reading 9.20 tsf	Dial Reading 18.40 tsf
0	.0695	.0855	.1122
.1	.0722	.0896	.1180
0.25	.0724	.0900	.1189
0.5	.0726	.0908	.1195
1	.0730	.0912	.1203
2	.0731	.0919	.1213
4	.0734	.0928	.1224
8	.0737	.0937	.1235
15	.0741	.0946	.1250
30	.0749	.0959	.1264
60	.0756	.0977	.1282
120	.0767	.0997	.1315
240	.0782	.1019	.1342
480	.0801	.1051	(511) .1389
1420	(1443) .08055	(1418) .1122	(1448) .1478

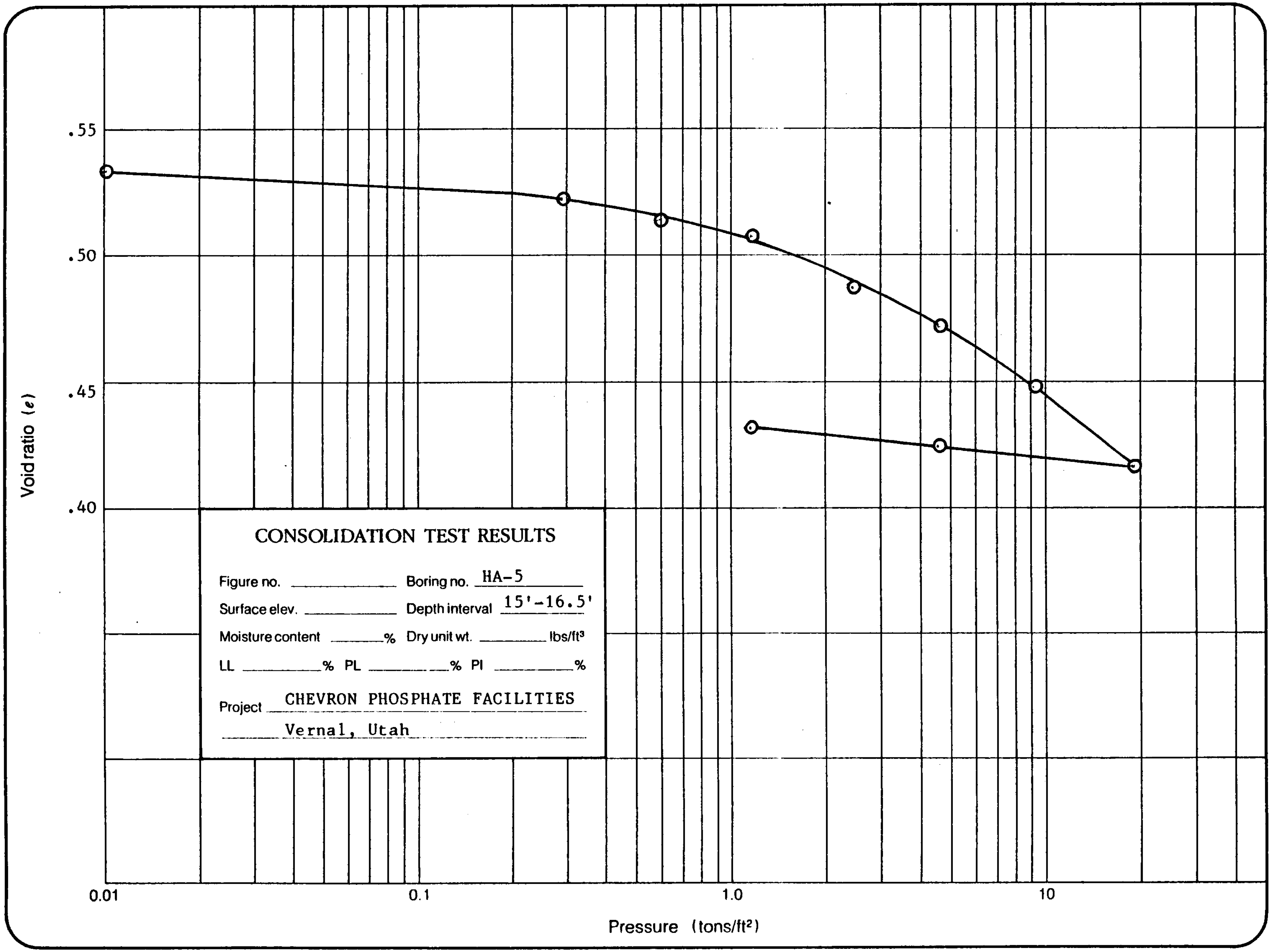
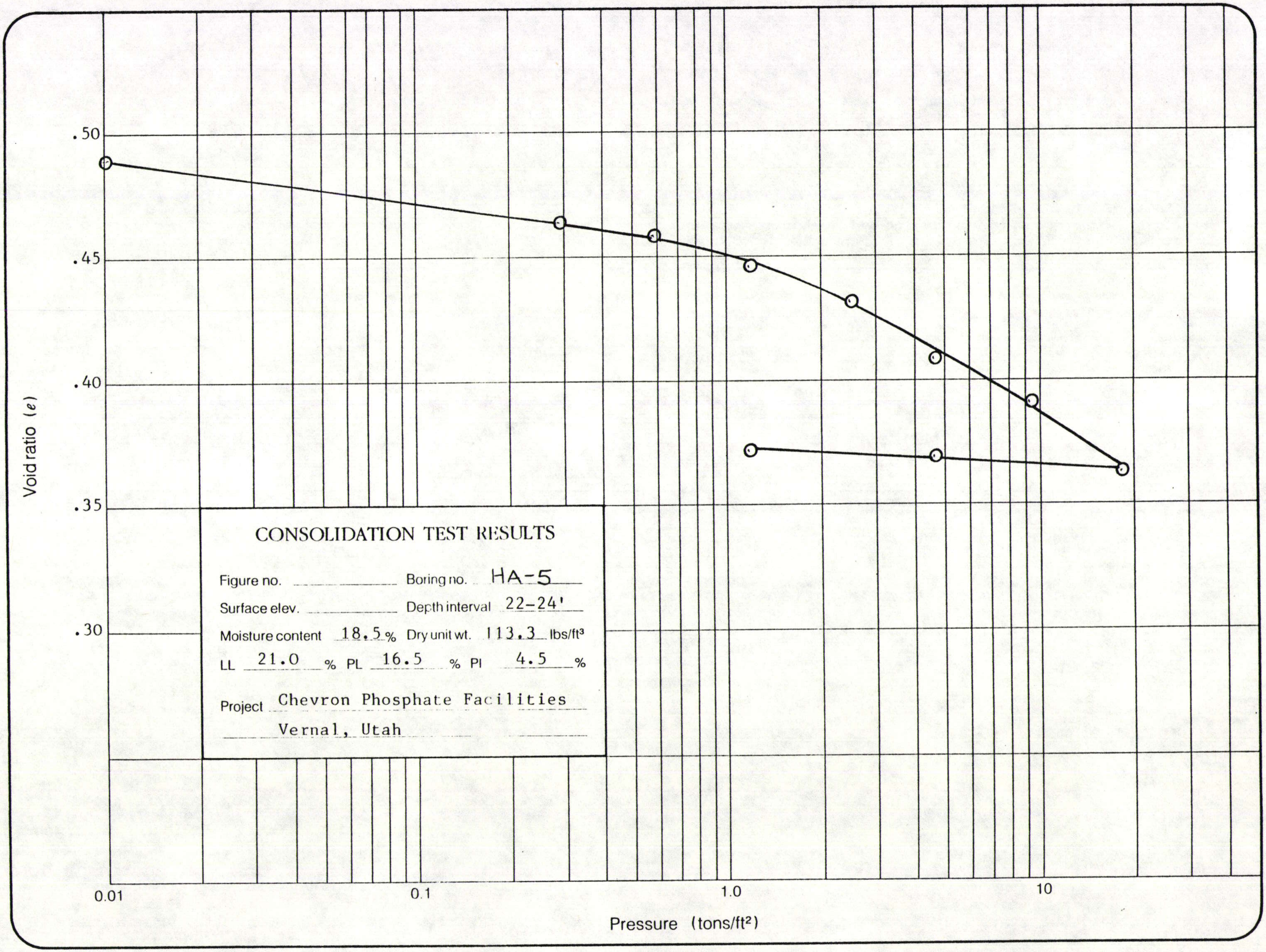

.55
.50
.45
.40
Void ratio (e)
0.01
0.1
1.0
10
Pressure (tons/ft²)
CONSOLIDATION TEST RESULTS
Figure no.
Boring no. HA-5
Surface elev.
Depth interval 15'-16.5'
Moisture content %
Dry unit wt. lbs/ft³
LL % PL % PI %
Project CHEVRON PHOSPHATE FACILITIES
Vernal, Utah

Table No. 2
Time Consolidation Test
Sample HA-5, 15-16.5 feet

Elapsed Time, min.	Dial Reading 0.58 tsf	1.15 tsf	2.30 tsf
0	.0544	.0596	.0664
.1	.0559	.0617	.0693
0.25	.0561	.0621	.0696
0.5	.0563	.0623	.0699
1	.0565	.0626	.0702
2	.0566	.0628	.0705
4	.0568	.0630	.0708
8	.0570	.0632	.0711
15	.0571	.0635	.0715
30	.0573	.0638	.0718
60	.0576	.0641	.0722
120		.0644	.0727
240	(180) .0581	.0648	.0733
480	(435) .0587	.0654	.0741
1420	(1415) .0596	(1422) .0664	(1426) .0764

Time Consolidation Test Cont.
Sample HA-5, 15-16.5 feet

Elapsed Time, min.	Dial Reading 4.60 tsf	9.20 tsf	18.40 tsf
0	.0764	.0872	.1027
.1	.0797	.0924	.1097
0.25	.0801	.0929	.1105
0.5	.0804	.0933	.1111
1	.0807	.0939	.1118
2	.0810	.0943	.1126
4	.0813	.0949	.1133
8	.0817	.0955	.1140
15	.0820	.0960	.1147
30	.0825	.0967	.1156
60	.0829	.0976	.1164
120	.0835	.0984	.1176
240	.0842	.0994	.1187
480	.0851	.1004	(513) .1204
1420	(1444) .0872	.1027	(1447) .1230



CONSOLIDATION TEST RESULTS

Figure no. ______ Boring no. HA-5

Surface elev. ______ Depth interval 22-24'

Moisture content 18.5 % Dry unit wt. 113.3 lbs/ft³

LL 21.0 % PL 16.5 % PI 4.5 %

Project Chevron Phosphate Facilities

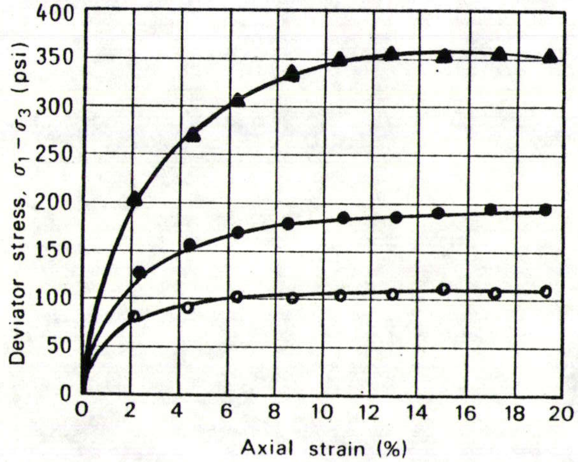
Vernal, Utah

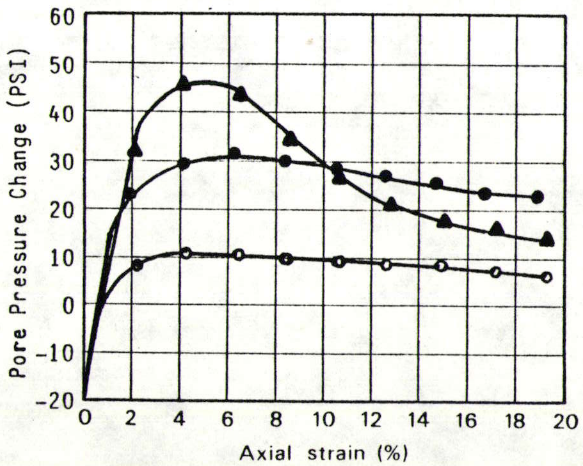
Time Consolidation Test
Sample HA-5, 22-24 feet

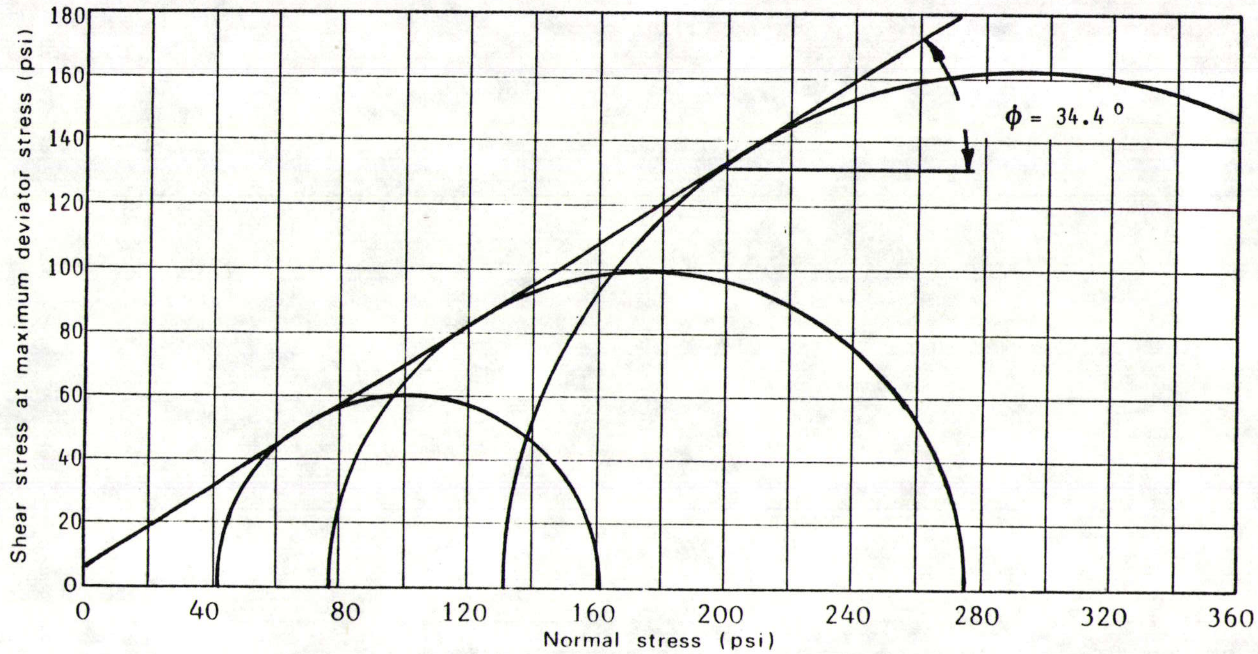
Elapsed Time, min.	Dial Reading 0.58 tsf	Dial Reading 1.15 tsf	Dial Reading 2.30 tsf
0	.0908	.0941	.1024
.1	.0908	.0961	.1095
0.25	.0908	.0967	.1096
0.5	.0909	.0972	.1098
1	.0911	.0977	.1101
2	.0914	.0981	.1102
4	.0917	.0984	.1103
8	.0920	.0988	.1106
15	.0923	.0991	.1109
30	.0926	.0994	.1110
60	.0928	.0997	.1111
120	.0930	.1001	.1112
240	.0932	.1004	.1113
480	.0936	(444) .1009	.1114
1420	.0941	(1421) .1024	(1440) .1116

Time Consolidation Test
Sample HA-5, 22-24 feet

	Dial Reading		
Elapsed Time, min	4.60 tsf	9.20 tsf	18.40 tsf
0	.1116	.1282	.1393
.1	.1155	.1300	.1496
0.25	.1165	.1307	.1499
0.5	.1172	.1314	.1500
1	.1179	.1320	.1503
2	.1184	.1326	.1506
4	.1188	.1332	.1509
8	.1193	.1337	.1516
15	.1198	.1342	.1524
30	.1203	.1347	.1531
60	.1208	.1353	.1540
120	.1214	.1361	.1549
240	.1220	.1368	.1559
480	.1270	(509) .1378	.1570
1420	(1415) .1282	(1447) .1393	(1434).1590







Test no. or symbol	Boring no. or depth	Sample data: Dry density (pcf)	Sample data: Moisture content (%)	Degree of saturation (%)	Confining pressure (psi)	Maximum deviator stress (psi)	Strength values at failure: Friction angle ϕ (degrees)	Strength values at failure: Cohesion (c/psi)	Sample size, L/D (inches)	Strain rate (inches/ minute)
○	15'–16.5'	110.0	19.3	100	43.0	119.3	34.4	2.0	2.8/ 1.32	.0016
●	15' – 16.5'	110.0	19.3	100	77.0	205.1	34.4	2.0	2.8/ 1.32	.0016
▲	22' – 24'	114.5	20.2	100	134.9	364.1	34.4	2.0	2.8/ 1.32	.0016

ROLLINS, BROWN AND GUNNELL, INC.
PROFESSIONAL ENGINEERS

TRIAXIAL SHEAR TEST
Project: CHEVRON PHOSPHATE FACILITIES
Vernal, Utah

HOLE NO. HA-5
DEPTH: 15' – 24'

FIGURE NO.

Table No. 3

Triaxial Shear Test
HA-5, 15-16.5

Dry Unit Weight	110.0
Natural Moisture Content	19.3
Confining Pressure	50 psi

Strain	Deviator Stress, psi	Pore Pressure psi
0.0214	83.3	39.4
0.0428	97.1	37.9
0.0643	105.1	38.3
0.0857	109.3	39.3
0.1071	110.5	39.4
0.1286	111.5	40.3
0.1500	114.0	40.9
0.1714	117.1	42.6
0.1929	118.9	42.8
0.2000	119.3	43.0

Table No. 4

Triaxial Shear Test
HA-5, 15-16.5 feet

Dry Unit Weight	110.0
Natural Moisture Content	19.3
Confining Pressure	100 psi

Strain	Deviator Stress, psi	Pore Pressure psi
0.0214	136.2	75.3
0.0428	163.5	69.3
0.0643	172.6	68.7
0.0857	183.4	71.0
0.1071	186.0	71.5
0.1286	189.2	72.8
0.1500	196.3	73.5
0.1714	205.1	77.0
0.1929	204.6	77.4
0.2000	204.7	77.5

Table No. 5

Triaxial Shear Test
HA-5, 22-24 feet.

Dry Unit Weight	114.5
Natural Moisture Content	20.2
Confining Pressure	150 psi

Strain	Deviator Stress, psi	Pore Pressure, psi
0.0214	218.6	116.8
0.0428	278.0	102.1
0.0643	306.2	105.1
0.0857	343.3	115.7
0.1071	354.7	122.2
0.1286	363.4	128.5
0.1500	365.4	131.5
0.1714	360.6	133.3
0.1929	364.1	134.6
0.2000	364.1	134.9

CHEVRON RESEARCH COMPANY
RICHMOND, CALIFORNIA

PETROGRAPHIC DESCRIPTION OF VERNAL TAILINGS DAM WALL ROCK CORES

Author - J. V. Heyse

HA 8 (Red Rock) Gypsum-Cemented Coarse Siltstone

The rock consists of well-sorted quartz grains of approximately 50 microns in size abundantly cemented and veined by gypsum. The cement is stained red by fine-grained hematite and goethite. Trace constituents of the rock include: potassic feldspar, hematite, and rutile grains; dolomite cement; and chips of ferruginous mudstone.

HA 7 (White Rock) Gypsum

The rock consists of scattered 50-micron dolomite crystals in a very abundant groundmass of fibrous gypsum. Red layers in this rock consist of less gypsum and more dolomite plus some quartz grains and fine-grained hematite and goethite.

:dc

Northern Engineering and Testing, Inc.
400 West 900 North
Building #8
P. O. Box 261
North Salt Lake City, Utah 84054
(801) 298-9314

TECHNICAL REPORT

AMERICAN COUNCIL OF INDEPENDENT LABORATORIES INC.

Copy to IECO
Pat Griffin.

Report to:

Chevron Resources
Attn: Mr. Howard Abplanalp
Manila Star Route
Vernal, Utah 84078

Date: May 14, 1985
Job Number: 84-2320
Sheet: 1 of 1
Invoice No.: 21062

Report of: Laboratory Tests of Rock Core Samples

Sample Identification RED MOENKOPI SHALE FROM SOUTH BORROW AREA.

On May 1, 1985, we received at our laboratory two samples of rock core. At your request, we performed a specific gravity, absorption, and magnesium sulphate soundness tests in accordance with ASTM C97 and ASTM C88, respectively.

The test results are summarized as follows:

Test Results

Sieve Analysis - After Crushing	HA-8 17'-19' Lab No. 3443	HA-7 10.2'-12.2' Lab No. 3442
Sieve Size	PERCENT	PASSING
3"	100	100
2"	95	82
1 1/2"	36	28
1"	14	10
3/4"	6	5
1/2"	4	3
3/8"	3	2
No. 4	2	1
Specific Gravity and Absorption		
Bulk Specific Gravity, SSD	2.49	2.50
Absorption, %	3.0	0.7
Magnesium Sulphate Soundness		
Percent Loss after 5 cycles	100	50

Reviewed by Curt Clint

This page is a reference page used to track documents internally for the Division of Oil, Gas and Mining

Mine Permit Number M0470007 Mine Name Vernal Phosphate
Operator SF Phosphate Co Date August 15 - 1985
TO ______ FROM ______

__CONFIDENTIAL __BOND CLOSURE __LARGE MAPS X EXPANDABLE
__MULTIPUL DOCUMENT TRACKING SHEET __NEW APPROVED NOI
__AMENDMENT __OTHER ______

Description YEAR-Record Number

__NOI X Incoming __Outgoing __Internal __Superceded

Enlargement of Existing TAlings Dam
Final Design Report

__NOI __Incoming __Outgoing __Internal __Superceded

__NOI __Incoming __Outgoing __Internal __Superceded

__NOI __Incoming __Outgoing __Internal __Superceded

__TEXT/ 81/2 X 11 MAP PAGES __11 X 17 MAPS __LARGE MAP

COMMENTS: ______

CC: ______